Essays in Macroeconomics and Finance

Cenkhan Sahin

Publisher: University of Groningen, The Netherlands
Printer: Ipskamp Drukkers B.V.
ISBN: 978-94-034-0810-1 / 978-94-034-0809-5 (eBook)

The views expressed in this thesis do not necessarily reflect the views of De Nederlandsche Bank, Sveriges Riksbank, or the Eurosystem.

university of groningen

Essays in Macroeconomics and Finance

Proefschrift

ter verkrijging van de graad van doctor aan de
Rijksuniversiteit Groningen
op gezag van de
rector magnifucus prof.dr. E. Sterken
en volgens besluit van het College voor Promoties.

De openbare verdediging zal plaatsvinden op

maandag 2 juli 2018, om 16:15 uur

door

Cenkhan Sahin

geboren op 18 november 1985
te Warnsveld, Nederland

Promotores
Prof.dr. J. de Haan
Prof.dr. F. R. Smets

Copromotor
Dr. A. Colciago

Beoordelingscommissie
Prof.dr. S.C.W. Eijffinger
Prof.dr. K.F. Roszbach
Prof.dr. R. Wouters

For dad.

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"Debt is key."

Chapter 1

Introduction

The unifying theme in this thesis stems from questions that have risen in the aftermath of, what has been deemed, one of the worst financial crises in modern economic history.

The crisis initially erupted in the US housing market. Following the collapse in house prices, many households witnessed the value of their homes drop below their mortgage. In the decades before the crisis, the United States had witnessed a dramatic rise in household debt. Mortgage debt as a percentage of residential value displayed a steady growth after the start of the eighties before taking off dramatically between 2000–07. The total amount of household debt in fact doubled during these years.[1] The rise of household indebtedness prior to the recent crisis is not a unique episode in economic history. A key similarity between the "Great Recession"—the period ensuing the financial crisis—and the Great Depression of the thirties is the rise of household debt. From 1920 to 1929, there was a dramatic increase in both mortgage debt and instalment debt for purchasing automobiles and furniture (Persons, 1930). According to Olney (1999), it was at this time that consumer attitudes toward borrowing had begun to change, and purchasing on credit increasingly became the standard. Especially for durable goods a potential buyer would use debt to make a purchase. Persons concluded that: "The past decade has witnessed a great volume of credit inflation. Our period of prosperity in part was based on nothing more substantial than debt expansion" (p.116). Households burdened with debt witnessed sharp falls in their spending — as they did again during the Great Recession.

The recent rise in household debt was not unique to the US.[2] Indeed, during the past two decades, many developed countries had large increases in household indebtedness and subsequently suffered from declines in household spending. Accordingly, consumption fell most sharply in those countries that had witnessed enormous increases in household debt: a relation that seems to hold in many other crises (Reinhart and Rogoff, 2008). Indeed, the economic costs of financial crises may vary considerably depending on the leverage incurred during the previous expansion phase (Jordà et al., 2013). The relation between elevated household debt, asset-price falls, and severe contractions therefore seems ironclad.

All of this indicates that debt is key. If debt generates severe recessions it is fundamentally important that we understand what policy can do about it. This thesis is centred around three agents in the economy: households, banks, and the government and addresses questions ranging from macroeconomic stability to financial stability and the role of policy. To be more specific, the thesis addresses the following research questions:

- What is the role of mortgage interest deduction in household indebtedness, foreclosures, and macroeconomic fluctuations?
- How did supervisory bank stress tests, conducted in the aftermath of the crisis, affect financial markets in the US and Europe?

[1] Chapter 2 provides an in-depth overview of the housing market in the US.

[2] For example, Glick et al. (2010) find that, compared with the US, the increase in household debt between 2000 to 2007 was even larger in Ireland, Denmark, Norway, the United Kingdom, Spain, Portugal, and the Netherlands.

- How did government-owned banks perform during the build-up to the recent financial crisis?

This thesis is loosely centred around these questions and consists of four chapters. I discuss each in turn next. The first chapter considers the macroeconomic effects of a popular housing policy in many countries: the mortgage interest deduction.[3] The mortgage interest deduction policy allows home owners to deduct mortgage interest payments from their taxes. As a result, home ownership is deemed more accessible. Although there are many papers studying the benefits (and costs) of this policy from a microeconomic perspective, I consider its merits in the context of a macro-prudential approach and ask how a tax policy that favours debt over equity may encourage high leverage and contribute to home owners having negative equity. There is evidence suggesting that the deduction policy increases the demand for mortgages and, as a result, household indebtedness (e.g. Martins and Villanueva, 2006). Again this observation is not unique to the US. For example, from an international perspective, Lea (2010) argues that countries with mortgage interest deductibility have exhibited faster mortgage growth. To understand the macroeconomic effects of mortgage interest deduction and the occurrence of foreclosures a model is needed that can adequately describe the housing market.

The proposed model in Chapter 2 works as follows. There are borrowers and savers in the economy. The borrowers borrow in the form of mortgage contracts from lenders, and these mortgage contracts require an interest payment each period. Importantly, the borrowers can deduct their interest payments from their taxes. In the event a borrower is unable to pay, the lender can foreclose the assets of the borrower. If the house price falls and the borrower sells, the full amount of the mortgage still has to be met. The shock to the value of the house then leads to a sharp drop in spending of debt-burdened consumers. The impact of this fall is amplified in two ways in the model. Firstly, consumers stop spending because they need to rebuild their net worth in order to smooth consumption for the future. Consumers also cut spending due to tighter borrowing constraints, as these are, typically tied to income and collateral. Secondly, underwater households are more likely to default on their mortgage payments. Defaults lead to foreclosures that in turn lead to further house price falls. Spending cuts driven by the initial decline in home values are further amplified as foreclosures push house prices further down. The aim of the study is to account for fluctuations in aggregate data. To validate the model the chapter therefore provides a variety of US housing and mortgage market characteristics. The simulated model is capable of matching key business cycles statistics in the United States.

The model has the following findings. Firstly, a drop in consumer spending is smaller with a lower rate of deductibility. Secondly, house prices, household leverage, and the

[3] This chapter is published as Sahin (2016).

rate of mortgage default are all lower with a lower rate of deductibility. Finally, when mortgage risk is high, the presence of deductibility leads to more volatile responses of the main macroeconomic variables to exogenous shocks. Overall, the empirical evidence and theoretical analysis presented in the chapter support the idea that mortgage interest deductibility may be a relevant factor in the occurrence of homeowner foreclosures.

Chapter 3 deals with the aftermath of the financial crisis.[4] Specifically, once the crisis materialised in early 2009 the question regulators were challenged with was: How can we restore confidence during a crisis? To calm the markets what was needed was transparency for otherwise conventionally opaque institutions. Regulators devised a novel strategy. They would conduct a "stress test". Specifically, regulators would delve into the books of major financial firms to calculate how much additional capital they would need to survive a truly catastrophic downturn. The banks would then be required to raise enough capital to fill the gap, if any. And if an unhealthy bank was unable to raise enough from private investors, the government would inject the missing capital. It would be a mechanism to recapitalise the financial system so that banks would have the resources to promote rather than prevent growth (Geithner, 2015).

The outcomes of the Supervisory Capital Assessment Program (SCAP)—as the stress test came to be called—of the 19 largest banks in the US were first disclosed on May 7, 2009. Since then the Federal Reserve implemented two supervisory programs. The first program, the Comprehensive Capital Analysis and Review (CCAR), assesses the capital planning processes and capital adequacy of banks and has been conducted annually since 2011. The CCAR links quantitative stress test results with qualitative assessments of capital planning processes of banks. The second program stems from the Dodd-Frank Act and requires assessing how bank capital levels would fare in stressful scenarios. The first Dodd-Frank Act Stress Test (DFAST) results were publicly released on March 7, 2013. It is widely believed that these stress tests, and their successors, have provided valuable information to the market.

Uncertainty is at the heart of financial crises. Stress tests, which are by design forward looking scenario analyses assessing the health of banks, therefore aim to impose transparency and calm the markets. The aim of Chapter 3 (and in part Chapter 4) is to assess how successful these policies have been. Specifically, the chapter examines the impact of stress tests in the US on banks' stock prices, credit default swap (CDS) spreads, systematic risk (proxied by banks' betas), and systemic risk over the 2009–15 period. The findings indicate that the release of stress test outcomes had little effect on stock returns in the very short-term but impacted CDS spreads in many years. The analysis of systematic risk also indicates that betas were affected by the publication of the outcomes of nearly

[4] This chapter is joint work with Ekaterina Neretina and Jakob de Haan and is published as Neretina, Sahin, and de Haan (2014).

all stress tests. In fact, the chapter presents evidence that the decline in systematic risk was in part driven by the correlation of the banks' stocks with the market. This finding is interpreted as a decrease in systemic risk. Stress tests have therefore been very successful in calming the markets. Indeed, according to Geithner (2015): "During the week of the stress test [SCAP], the price of credit default swaps for the six largest banks dropped by a third. And by the time the results were in, the index of financial stocks had more than doubled since hitting bottom in early March. As our strategy became clearer, and fears of widespread nationalisation faded, confidence returned to the financial system, and confidence bred stability. The system had become investable again."

The Fed was not alone in its endeavours to stabilise financial markets. On 23 October 2013, the European Central Bank (ECB) announced an assessment in preparation for its new task as banking supervisor in the euro area. The "Comprehensive Assessment" consisted of an asset quality review and a stress test. Its aim was to scour banks' books for hidden problems, test their ability to withstand crises, and force weak banks to raise more capital. The ultimate aim was to clear up lingering doubts about the health of banks in the euro area, so that banks can raise funds more easily and increase lending.

As Chapter 4 shows, although the results of the Comprehensive Assessment have had limited immediate market-wide effects, for some banks the assessment has led to increased transparency, as markets responded to the provision of new information.[5] The success of the assessment—and stress tests in general—is however not primarily determined by short-term market responses. As a result of the exercise, the ECB knows more about the current state of the banks and can use this information in implementing its new responsibility for bank supervision in the Eurozone. Moreover, due to the Comprehensive Assessment several banks have enhanced their capital base which in turn enhances financial stability.

The crisis resulted in many banks being nationalised. This inevitably led to an increase in government bank ownership. Government ownership of banks has always been controversial among economists. Most agree that, generally, government ownership of banks is inefficient. The inefficiency usually stems from weak governance structures, unstable business models, misaligned incentives, or otherwise a general lack in banking skills resulting in higher costs and lower profitability. Nevertheless, some economists also agree that, especially during turbulent times, the presence of government-owned banks can provide economic stability.

Chapter 5 aims to address an important question that has received scant attention in the literature, namely how does government ownership of banks affect banks' risk taking prior to a downturn. Specifically, how did government-owned banks perform prior to

[5] This chapter is joint work with Jakob de Haan and is published as Sahin and de Haan (2016).

the meltdown in 2008? During the build-up to the crisis some of the risks on the loan books of banks may be present and rising but may not have as of yet materialised fully resulting in loans becoming non-performing. For this purpose the final chapter analyses cross-sectional evidence of bank characteristics of many banks for mostly European countries over the period 2004–2007. Focusing on a large sample of mainly non-listed banks during a period of exuberance facilitates an in depth discussion of the performance of government-owned banks and allows for a stark contrast with existing studies. The findings are corroborating. Firstly, the descriptive findings indicate that government-owned banks are ubiquitous. Secondly, across the entire sample, these banks perform below average when it comes to bank performance measures. Finally, using balance sheet measures for bank riskiness the findings consistently show that if a bank is government-owned it is, all else equal, riskier. This finding holds after controlling for a variety of bank-specific and macroeconomic variables and is robust to alternative measures of bank riskiness. It seems that even during an exuberant boom government ownership of banks is inefficient and ceteris paribus more risky.

Based on the findings in each chapter, this thesis suggests the following key points concerning the role of policy.

- It is important to understand housing market outcomes in the context of macroprudential policy. Policies aimed at aiding home owners on a microeconomic level may prove dangerous from a macroeconomic perspective.
- In contrast, policies designed to assuage markets in dismay by pushing for more information and transparency may prove very beneficial from a financial stability perspective. Moreover, assessments such as stress tests enable the regulators forward that cause.
- Considering the pre-crisis period of 2004–07, which displayed a tremendous rise in debt, the conventional view among economists remains unscathed: Government ownership of banks is inefficient and ceteris paribus more risky. This implies that banks that were nationalised during the financial crisis should be denationalised.

Chapter 2

Macroeconomic effects of mortgage interest deduction

"We don't want any scandals in Edgewood.
It brings down the property value."

The recent financial crisis initially erupted in the housing market but it took decades of debt absorption to reach critical levels of leverage. How do tax features that favour debt over equity affect foreclosures?

2.1 Introduction

The economic developments during the Great Recession have taught us that mortgages and housing are fundamental elements to understand the nature of crises. An important feature of the housing market in the US is the tax treatment that promotes homeownership. There is wide evidence that mortgage interest deductibility increases house prices and household leverage (e.g. Hendershott and Pryce, 2006; Martins and Villanueva, 2006). During busts, due to the decline in the value of real estate, foreclosures rise. From a macro-prudential perspective, it is necessary to understand features that could potentially contribute to the building up of financial imbalances and excessive household debt, thereby magnifying the problem. Tax features, such as mortgage interest deduction, necessarily favour debt over equity and therefore may encourage high leverage. For this purpose I construct a model where borrowing and lending by households leads to mortgage defaults in equilibrium. Within this setting, I examine the general equilibrium effects of mortgage interest deduction on house prices, leverage, mortgage default, and real activity. I first develop a model featuring an economy with households, firms, and a government. Households issue loans and purchase mortgage portfolios and in addition deduct interest from their mortgage payments. The government funds the deduction of mortgage interest with lump-sum taxes. In order to model default there is an idiosyncratic shock to the value of housing after households have signed a mortgage contract. At maturity, depending on the realisation of the shock, some households default on their mortgage. To understand the consequences for the real economy I discuss the dynamics of the model with productivity, preference, and mortgage riskiness shocks. Since the model features tax-deductible mortgage payments it is appropriate for analysing the macroeconomic effects of mortgage interest deduction.

Deductibility of mortgage interest is a mean of extending the fundamental tax advantage of owner occupied housing. The primary reason for its existence is to incentivise homeownership. The subsidy is also claimed to have positive externalities such as lower crime rates, higher voting rates, better care and maintenance of property, investment in the local community, and social mobility through asset accumulation (see for an overview Dietz and Haurin, 2003). Despite its merits, the mortgage interest deduction has also been subjected to criticism. Opponents of the policy stress the large share of owner-occupied housing entries in the annual tax expenditure budget.[1] House prices and household leverage seem to go hand in hand with the mortgage interest deduction (Hendershott and Pryce, 2006; Martins and Villanueva, 2006; Ellis, 2010). Moreover, increasing house prices make homeownership less affordable for households with moderate to low incomes. There is evidence that deductibility feeds into house prices depending

[1] For example, the Office of Tax Analysis (2017) estimates the tax expenditure for the home mortgage interest deduction for fiscal years 2018–27 at a little over $1 trillion (i.e. $1,003 bln).

on housing supply conditions (Hilber and Turner, 2014). This is particularly the case in condensed regions. Section 2.2 elaborates in more detail on the microeconomic effects of preferential tax treatments.

The main findings can be summarised as follows. The proposed model can account for some of the key features of the mortgage market. House prices are higher in the presence of deductions and households will lever more the more they can deduct from their mortgage payments. Lowering the level of mortgage interest deduction for households will tighten their collateral constraint and, in equilibrium, lead to fewer delinquencies. The mechanism endogenously follows from the household optimisation. The findings suggest that the preferential tax treatment that exists in the housing market may be a relevant factor for our understanding of the occurrence of foreclosures.

The chapter is structured as follows. Section 2.2 briefly discusses some related literature and provides some empirical motivation. Section 2.3 describes a model of a mortgage market with mortgage interest deduction. Section 2.4 provides the findings. Finally, Section 2.5 concludes.

2.2 Literature and empirical evidence

A voluminous literature examines housing market outcomes in the context of federal tax policy. First, a wide strand of the literature considers the incentives for homeownership (e.g. Rosen and Rosen, 1980; Poterba, 1984; Rosen, 1985; Smith et al., 1988; Hanson, 2012; Hilber and Turner, 2014) and associated (positive) externalities (e.g. Glaeser and Shapiro, 2003; Dietz and Haurin, 2003; Fetter, 2013). Although early studies argue that the mortgage interest deduction increases homeownership, later papers question this. For example, Hilber and Turner (2014) highlight the perverse effects of the mortgage interest deduction in highly regulated housing markets where the supply of housing is inelastic. Rather than boosting homeownership, much of the tax benefit seems to be capitalised into housing prices making the tax benefit an ineffective policy tool.

Many papers consider the distribution, limitation or otherwise abolishment of the preferential tax treatment for housing (e.g. Litzenberger and Sosin, 1978; Rosen, 1979; Rosen et al., 1984; Berkovec and Fullerton, 1992; Follain and Melamed, 1998; Anderson and Roy, 2001; Stroebel and Floetotto, 2011; Jeske et al., 2013; Sommer and Sullivan, 2018). Other papers stress the asymmetry in benefits for households with differing incomes, or consider housing market outcomes in renting over ownership. For example, Poterba and Sinai (2008) argue that the subsidy rate is larger for households in higher marginal tax rate brackets implying that those who benefit from the deduction would own homes anyhow and the tax treatment therefore provides an incentive to live in more expensive houses rendering its purpose, promoting ownership over renting, in moot. Some papers

consider the distribution of tax benefits in the context of Tax Reform Acts (e.g. Poterba, 1992; Pechman, 1987; Maki, 2001). Poterba (1992) argues that the tax-exempt imputed income changed for homeowners after the TRA86 altering the distribution of the mortgage interest deduction benefit in favour of high income households. The findings of this literature point out that house prices are higher in the presence of deductions increasing the cost of homeownership.

Finally, a smaller literature examines the demand for mortgage debt, leverage, and foreclosures (e.g. Hendershott et al., 2002; Hendershott and Pryce, 2006; Martins and Villanueva, 2006) in the context of preferential tax treatment. From an international perspective, Lea (2010) argues that countries with mortgage interest deductibility have exhibited faster mortgage growth.[2] Ellis (2010) notes that the deductibility of interest combined with prepayment penalties may have contributed to the rise in household leverage in the US. The findings of this literature suggest that the tax saving as a result of deductions on mortgage interest is a significant determinant of the amount of mortgage debt and household leverage.

There are, in comparison, relatively a few papers taking a macro approach. Gervais (2002) studies the impact of the preferential tax treatment of housing capital in a dynamic general equilibrium life-cycle economy and finds that tax treatments such as the mortgage interest deduction result in distortions to the implicit rental income from owner-occupancy. In a related study to Gervais (2002), Chatterjee and Eyigungor (2015) consider in a quantitative setting the housing market and the foreclosure crisis. Their model of long-duration collaterised debt with risk of default shows that the rise of foreclosures in the recent crisis may have been smaller in the absence of preferential tax treatments.

This study contributes to the literature by presenting a model that is capable of representing the dynamics observed for mortgage demand and mortgage rates, real house prices, and delinquency rates in the US before the recent financial crisis.[3] I use a tractable model to represent the US mortgage market prior to the financial crisis of 2008 in a dynamic stochastic general equilibrium setting and understand the macroeconomic effects of deductions.[4] I model default in the mortgage market following an approach similar to Bernanke et al. (1999) by introducing idiosyncratic shocks to the value of housing. This set-up captures the inherent riskiness of mortgages. An additional key feature of the model is that agents are constrained in their borrowing by a collateral constraint fol-

[2] Most OECD countries allow for deduction in some form. The countries that allow itemisation in some form are Austria, Belgium, Czech Rep., Denmark, Estonia, Finland, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, and the US. The US allows nearly full deductibility without taxing imputed rent. Also see Andrews and Caldera Sánchez (2011) for the drivers of homeownership rates in OECD countries and Bourassa et al. (2013) for an international survey on mortgage interest deduction.

[3] Some studies consider the role of tax deductibility of mortgage interest during the recent financial crisis. This study abstracts from this narrative and instead is interested in the build-up phase of household indebtedness in general and the contribution of tax deductibility to foreclosures.

[4] Seminal contributions in the literature that use applied DSGE models are e.g. Smets and Wouters (2003), Christiano et al. (2005), and Smets and Wouters (2007).

lowing the seminal work of Kiyotaki and Moore (1997). The resulting model allows us to understand the relationship between mortgage interest deductibility, household indebtedness, foreclosures, and importantly, macroeconomic fluctuations.

Figure 2.1
The US mortgage market

Notes: This figure provides an overview of some key mortgage market series for the US considered in this study. The mortgage debt outstanding is for all holders, scaled by GDP and the market value of the total stock of real estate. The mortgage rate is the 30-year conventional mortgage rate. The real house price index denotes the quarterly all-transactions House Price Index for the United States, deflated with the GDP deflator. The delinquency rate denotes quarterly single-family residential mortgages booked in domestic offices for all commercial banks. Data on mortgage rates, mortgage debt outstanding, value of real estate, and the GDP deflator are retrieved from Federal Reserve Economic Data (FRED), Federal Reserve Bank of St. Louis. The House Price Index is retrieved from the Federal Housing Finance Agency.

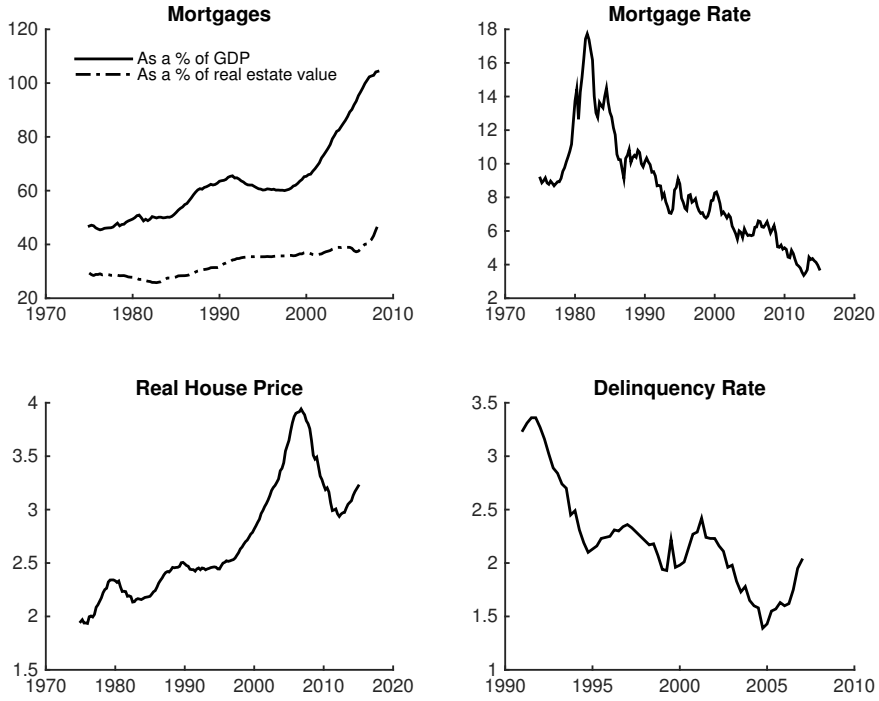
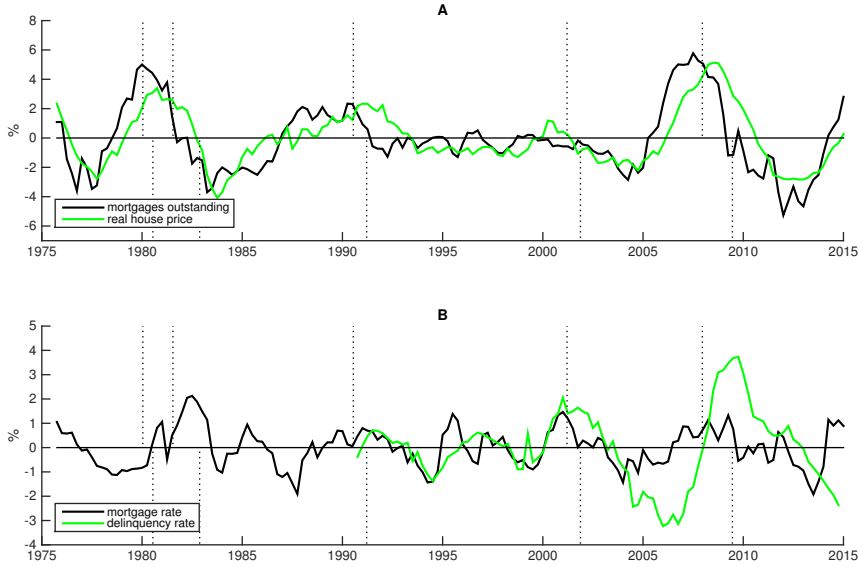


Figure 2.1 characterises the US mortgage market in the past decades. The figure portrays the increasing indebtedness of households during the 1980s and the subsequent boom in real house prices in 2000s. Mortgages have increased sharply as a percentage of GDP. Scaled by the value of real estate the increase in mortgages is markedly less when compared with mortgages as a percentage of GDP but considerable nonetheless. Fol-

lowing the rise in mortgage demand delinquency rates fall during the 1990s before they take off after 2006. Figure 2.2 plots the cyclical components of these series. The top panel displays the components of mortgages and house prices. Outstanding mortgages are somewhat more volatile than house prices. The series display a positive co-movement throughout the sample. The lower panel plots the cyclical components of the mortgage rate and delinquency rate. Delinquency rates are positively correlated with mortgage rates and are particularly more volatile following the boom and bust after 2000. Table 2.1 provides some figures on the correlation and standard deviations of these series relative to house prices. The delinquency rate shows a negative correlation with mortgage demand, mortgage rate and real house prices. The delinquency rate is also more volatile than house prices following the bust in 2007-08.

Figure 2.2
Cyclical components

Notes: This figure plots the cyclical components of mortgage debt outstanding, real house prices, delinquency rates, and mortgage rates. Series are log deviations from trend. Variables are HP-detrended with smoothing parameter 1600. For sources see Figure 2.1. NBER business cycle peaks and troughs are denoted by vertical dots above and below the time-axis, respectively.



To understand the relationship between house prices and default rates better it is useful to make a distinction between house price elasticities. Mian and Sufi (2011) show that most of the rise in house prices comes from Metropolitan Statistical Areas (MSAs) with

Table 2.1
Correlations and standard deviations in the data

Notes: All displayed values are for quarterly logged data. Variables are HP-detrended with smoothing parameter 1*e*5.

	House price	**Mortgages outstanding**	**Mortgage rate**	**Delinquency rate**
Correlations				
Mortgages outstanding	.8296	1		
Mortgage rate	.3958	.3618	1	
Delinquency rate	-.6145	-.1207	-.1979	1
Std dev relative to house price	1	1.422	1.259	4.825

inelastic housing supplies. Figure 2.3 plots house prices for the ten most inelastic and the ten most elastic MSAs in the US, confirming this picture. As mentioned, Hilber and Turner (2014) argue that the extent to which mortgage interest deduction affects house prices depends on local housing supply conditions. Much of the mortgage interest deduction seems to be capitalised into house prices in inelastic regions.

Figure 2.4 provides evidence that the average mortgage subsidy rate does not contradict this illustration. The figure shows that for MSAs that have inelastic housing supply there is a positive association with the average mortgage subsidy rate over the period 1984–2007. Moreover, the variation in mortgage interest rate subsidies used for deductions is not common across states.[5]

In what follows, a model is presented which can describe the US mortgage market. Subsequently, the effects of mortgage interest deductions are discussed.

[5]For example, Figure A2.1 in the Appendix shows that there is no particular uniform pattern.

Figure 2.3
House Price Index for selected MSAs

Notes: This figure plots the movements in house prices categorised according to the most ten inelastic and the ten most elastic Metropolitan Statistical Areas in the US with population greater than 500,000. Housing supply elasticities used follow Saiz (2008) (and Mian and Sufi (2011)). See Table A2.2 for an overview. House prices denote the quarterly all-transactions House Price Index for the United States retrieved from the Federal Housing Finance Agency.

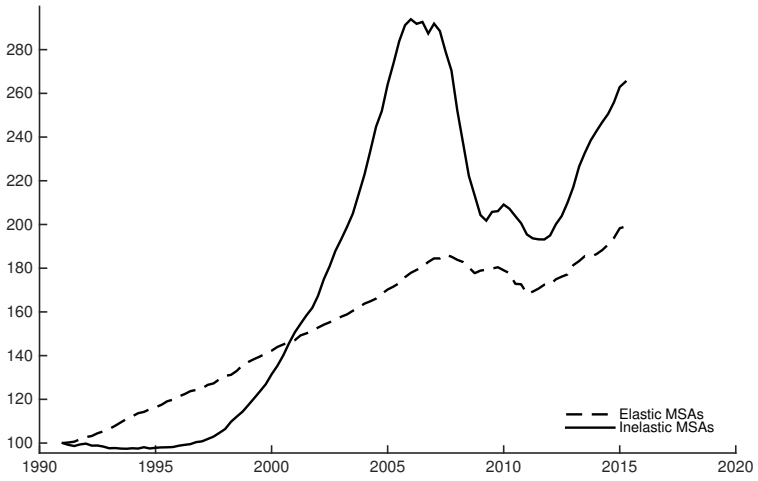
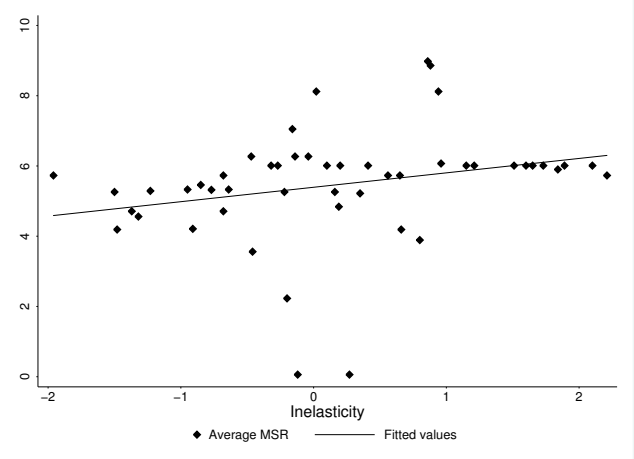


Figure 2.4
Mortgage subsidy rate and housing inelasticity

Notes: This figure plots the relationship between the average mortgage subsidy rate over 1984–2007 and housing supply inelasticities following Saks (2008). The scatterplot excludes MSAs where the mortgage interest deduction is not present. The plot only considers Metropolitan Statistical Areas in the US with population greater than 500,000. Housing regulation figures are retrieved from Saks (2008). See Table A2.2 for an overview.



2.3 Model

The structure of the model is as follows. There is a continuum of infinitely lived households which consume housing services and non-durable goods in an endowment economy with perfect insurance among household members. Households are divided into two groups. A fraction of ω are impatient and borrow in the model. The remaining fraction, $1-\omega$, are patient and are the lenders. Borrowers issue mortgage debt over which they pay interest net of mortgage interest deduction. Lenders purchase mortgage portfolios over which they receive gross returns. In order to understand the role of mortgage interest deduction in a business cycle setting, I introduce idiosyncratic shocks to the value of housing. If the realisation of this shock is below some cut-off value, to be specified below, the loan repayments will exceed the value of the house and therefore, borrowers will default on their mortgage.

2.3.1 Mortgage contract

There is a representative household with a continuum of members indexed by i. At period t, the household members engage in a one-period mortgage contract with collateral. At period t a household member decides on the amount of housing and the interest rate

that will be paid on its mortgage in period $t+1$. Upon maturity of the mortgage contract, a borrower experiences an idiosyncratic depreciation (appreciation) shock, $\varphi_{i,t+1}$, to its housing value. The idiosyncratic shock $\varphi_{i,t+1}$ is i.i.d. across household members and follows a normal distribution with mean one and standard deviation σ. The cumulative distribution function and the probability density function are denoted by $F(\varphi_{i,t+1})$ and $f(\varphi_{i,t+1})$, respectively. At maturity, borrowers experience idiosyncratic shocks and either repay the loan or default. In case of default, the borrower hands over the entire stock of housing to the lender.

Let $d_{i,t}$ and $r_{i,t}$ be the amount of mortgage debt and the interest rate on mortgage debt, respectively. The transfer to the lender at period $t+1$ is,

$$\begin{array}{ll} (1+r_{i,t})d_{i,t} & \text{if the borrower repays,} \\ p_{h,t+1}\varphi_{i,t+1}h_{i,t} & \text{if the borrower defaults,} \end{array}$$

where $p_{h,t+1}$ is the house price at period $t+1$ and $h_{i,t}$ is period t housing. Note that the interest rate is predetermined. The optimal default policy implies a cut-off value for the idiosyncratic shock. If the realisation of the idiosyncratic shock is below the cut-off level, the borrower will default. If the realisation is above the cut-off level, the borrower will repay the lender. The cut-off level therefore represents the marginal borrower who is indifferent between defaulting on the mortgage and repaying the lender. The optimal default policy follows from,

$$(1+r_{i,t-1}(1-\tau))d_{i,t-1} = p_{h,t}\bar{\varphi}_{i,t}h_{i,t-1}, \tag{2.1}$$

where τ is the fraction of mortgage interest that is tax-deductible and $\bar{\varphi}_{i,t}$ is a cut-off value of the idiosyncratic shock for which the borrower is willing to pay the mortgage debt at the contractual interest rate $r_{i,t-1}$. Note that the constraint in equation (2.1) resembles a collateral constraint as in Kiyotaki and Moore (1997) and Iacoviello (2005). As mentioned, if the realisation of $\varphi_{i,t+1}$ is below the cut-off $\bar{\varphi}_{t+1}$, the borrower defaults. The rate of default is denoted by $F(\bar{\varphi}_i)$.

Now consider the lender's side of the mortgage contract, specifically the lender's participation constraint. Lenders purchase a mortgage portfolio and can fully diversify the idiosyncratic shock and therefore bear only aggregate risk. However, lenders incur a cost in case the borrower defaults as in Bernanke et al. (1999).[6] Borrowers, in turn, will reveal their idiosyncratic shock satisfying equation (2.1). The gross return on a mortgage

[6] The cost of default could be interpreted as a monitoring cost for the lender to assess and seize the collateral in case of default (cf. Bernanke et al. (1999)). In order to keep the model as simple as possible I refrain from possible agency problems that justify the introduction of a monitoring cost. In the presence of a default cost mortgage contracts may not be optimal contracts. However, agents have incentives to use contracts due to their fiscal treatment.

portfolio for the lender is,

$$R_{m,t+1} = \frac{\left(1 - F\left(\overline{\varphi}_{i,t+1}\right)\right)(1 + r_{i,t})m_t + (1-\mu)\, p_{h,t+1} h_t \int_{-\infty}^{\overline{\varphi}_{i,t+1}} \varphi \mathrm{d}F(\varphi)}{m_t}, \tag{2.2}$$

where m_t denotes purchases of the mortgage portfolio and $0 < \mu < 1$ is a default cost parameter. The gross return on the mortgage portfolio is equal to the transfer at maturity in case the borrower repays and the housing stock net of default cost in case the borrower defaults. The expectation of the idiosyncratic shock in (2.2) represents the expected value of the idiosyncratic shock conditional on the shock being less than or equal to the cut-off value $\overline{\varphi}_{i,t+1}$. Note that the cut-off $\bar{\varphi}_{i,t}$ enters equation (2.2) exogenously since the default behaviour of the borrower is assumed to be known by the lender. The participation constraint of the lender is of the form,

$$1 = \mathbb{E}_t \Lambda_{t,t+1} \left\{ R_{m,t+1} \right\} \tag{2.3}$$

where $\Lambda_{t,t+1}$ is the stochastic discount factor of lenders. In the optimum, the utility derived from a marginal unit of current consumption equals the discounted expected value of the utility from the amount of future consumption. If equation (2.3) holds, the lender is indifferent between consumption today and investment in a mortgage portfolio delivering a return that is discounted using a stochastic discount factor. A binding participation constraint ensures the lender's optimality condition in equilibrium.

It is worth repeating the decision variables in the contract. The optimal mortgage contract involves sequences of durable and non-durable consumption, mortgage debt, mortgage interest rate, and the cut-off value of the idiosyncratic shock such that the lender's participation constraint (and the household budget constraint) are satisfied. By symmetry, all borrowers make the same choices in equilibrium and by construction households will sign a mortgage contract and not finance the durable good with their own funds.[7]

2.3.2 *Impatient households*

Impatient households derive utility according to the following function,

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln c_t + \eta z_{h,t} \ln h_t - \theta \ln n_t \right\},$$

where β is the discount factor, c_t and h_t denote time t consumption of non-durables and housing, respectively, $z_{h,t}$ is a time t housing preference shock, η is a housing preference

[7] In reality, households that are down-payment constrained have, in the face of rising house prices fuelled by the mortgage interest deduction, two possibilities: they can opt-out of the market or buy housing at the cost of increasing their leverage as house prices booms are rolled into the size of the mortgage. The latter approach suits the empirical evidence on household indebtedness presented earlier.

parameter, and n_t is the supply of labour.[8] The budget constraint of the households is,

$$c_t + p_{h,t}\left(h_t - h_{t-1}\right) + R_{d,t}d_{t-1} + T_t = w_t n_t + d_t, \tag{2.4}$$

where w_t denotes wage income, T_t is lump-sum tax, and $R_{d,t}$ is the gross interest rate paid on mortgage debt in period t for debt issued at time $t-1$. $R_{d,t+1}$ is denoted by,

$$R_{d,t+1} = \frac{\left(1 - F\left(\overline{\varphi}_{t+1}\right)\right)\left(1 + r_t\left(1-\tau\right)\right)d_t + p_{h,t+1}h_t\int_{-\infty}^{\overline{\varphi}_{i,t+1}}\varphi \mathrm{d}F\left(\varphi\right)}{d_t}. \tag{2.5}$$

where τ is the mortgage interest that is tax-deductible. In equation (2.5) gross interest payments on mortgage debt equal the transfer at period $t+1$ to the lender net of tax-deductible mortgage interest and the value of collateral.

Households choose sequences of non-durable consumption $\{c_t\}$, durable consumption $\{h_t\}$, labour $\{n_t\}$, mortgage debt $\{d_t\}$, mortgage interest rate $\{r_t\}$, and the cut-off value of the idiosyncratic shock $\{\overline{\varphi}_t\}$ to maximise utility subject to the budget constraint (2.4), the participation constraint (2.3), and the gross returns on the mortgage portfolio and debt, equations (2.2) and (2.5), respectively.

2.3.3 *Equilibrium conditions*

The first order condition for housing is,

$$\begin{aligned}\frac{p_{h,t}}{c_{i,t}} = \frac{\eta z_{h,t}}{h_{i,t}} &+ \mathbb{E}_t\beta\left\{\frac{p_{h,t+1}}{c_{t+1}}\left(1 - \int_{-\infty}^{\overline{\varphi}_{t+1}}\varphi \mathrm{d}F\left(\varphi\right)\right)\right\} \\ &+ \mathbb{E}_t\Lambda_{t,t+1}\left\{\lambda_t\left(1-\mu\right)\frac{p_{h,t+1}}{d_t}\int_{-\infty}^{\overline{\varphi}_{t+1}}\varphi \mathrm{d}F\left(\varphi\right)\right\} - \lambda_{2,t}(1 + r_t\left(1-\tau\right))\frac{d_t}{h_t^2},\end{aligned} \tag{2.6}$$

where λ_t and $\lambda_{2,t}$ are the Lagrange-multipliers on the participation constraint and the collateral constraint, respectively. The right hand side of equation (2.6) represents the shadow value of housing and consists of four terms. The first one is the direct utility gain from consuming an additional unit of housing. The second term is the utility derived from the continuation value of the house in period $t+1$. The last two terms stem from the additional burden to satisfy the lender's participation and collateral constraints. In equation (2.3) (and implicitly in equation (2.1)) a household with higher durable consumption is less likely to default, and less likely to incur a default cost. At the optimum, the shadow value of housing must be equal to the utility derived from $p_{h,t}$ marginal units of non-durables. Households supply labour according to,

$$w_t/c_t = \theta/n_t. \tag{2.7}$$

[8] In a representative context the i index is omitted.

The Euler equation for mortgage demand is given by,

$$\frac{1}{c_t} = \mathbb{E}_t \beta \left\{ \frac{\left(1 - F\left(\overline{\varphi}_{t+1}\right)\right)\left(1 + r_t\left(1 - \tau\right)\right)}{c_{t+1}} \right\} + \mathbb{E}_t \Lambda_{t,t+1} \left\{ \lambda_t \left(1 - \mu\right) p_{h,t+1} \frac{h_t}{d_t^2} \int_{-\infty}^{\overline{\varphi}_{t+1}} \varphi \mathrm{d}F\left(\varphi\right) \right\} - \lambda_{2,t}\left(1 + r_t\left(1 - \tau\right)\right)\frac{1}{h_t}. \quad (2.8)$$

In equation (2.8) an extra utility value of consumption today by the borrower must equal the right hand side which consists of three terms. The first term is the repayment at maturity adjusted for a default probability and mortgage interest deduction. The second term captures the additional burden of satisfying the lender's participation constraint. The final term stems from the collateral constraint. The demand and supply of mortgages are plotted in Figure 2.5.

The first order condition for the interest rate on mortgage debt is,

$$\mathbb{E}_t \beta \left\{ \frac{\left(1 - F\left(\overline{\varphi}_{t+1}\right)\right)\left(1 - \tau\right))d_t}{c_{t+1}} \right\} = \mathbb{E}_t \Lambda_{t,t+1} \left\{ \lambda_t \left(1 - F\left(\overline{\varphi}_{t+1}\right)\right) + \lambda_{2,t}\left(1 - \tau\right)\frac{d_t}{h_t} \right\}. \quad (2.9)$$

Finally, the first order condition for the cut-off value of the idiosyncratic shock is given by,

$$p_{h,t}\overline{\varphi}_t h_{t-1} = \left(1 + r_{t-1}\left(1 - \tau\right)\right)d_{t-1}.$$

2.3.4 *Patient households*

The remaining fraction of households $(1 - \omega)$ has discount factor γ, with $\gamma > \beta$. The decision variables for patient households are denoted with a prime. In equilibrium patient households will lend to impatient households. Lenders choose sequences of non-durable consumption $\{c_t'\}$, housing services $\{h_t'\}$, labour $\{n_t'\}$, and mortgage portfolios $\{m_t\}$ such that their budget constraint is satisfied. The optimality conditions for mortgage supply, housing, and labour supply are similar to (2.3), (2.6), and (2.7), respectively. The borrowing constraint however does not apply to the patient households so that the lagrange multipliers are always zero.

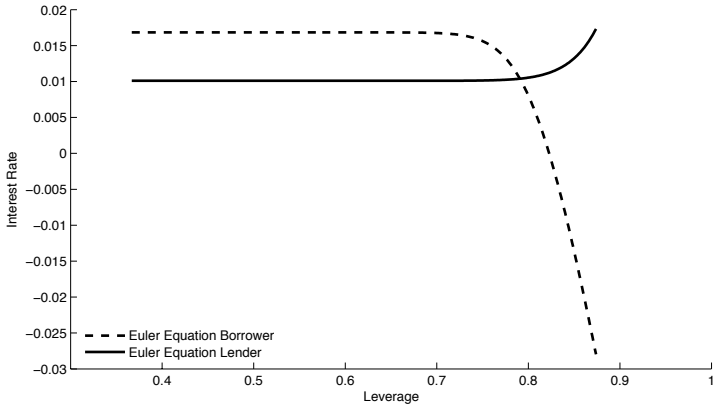
2.3.5 *Firms*

Following Iacoviello and Neri (2010) labour enters the production function in a Cobb-Douglas fashion. The firms in the economy produce output according to,

$$y_t = z_{a,t} n_t^{\alpha} n_t'^{(1-\alpha)} \quad (2.10)$$

Figure 2.5
Demand and supply of mortgages

Notes: This figure plots the demand and supply of mortgages using the Euler conditions of the lender and borrower following Equations (2.3) and (2.8), respectively. Leverage is denoted as loan-to-value and equals $d/p_h h$.



where $z_{a,t}$ is a technology shock. Profit maximisation implies $w_t = \alpha y_t/n_t$ and $w'_t = (1-\alpha)y_t/n'_t$.

2.3.6 *Government*

The role of the government in this economy is to ensure that mortgage interests are deductible from taxes. The government budget constraint is,

$$T_t = \left(1 - F\left(\overline{\varphi}_t\right)\right) r_{t-1} \tau d_{t-1}. \tag{2.11}$$

2.3.7 *Exogenous processes*

Production technology is modelled exogenously and the corresponding process evolves according to the following law of motion,

$$\ln z_{a,t} = \rho_a \ln z_{a,t-1} + \varepsilon_{a,t}, \tag{2.12}$$

where $\varepsilon_{a,t}$ is an i.i.d. innovation that has a normal distribution with mean zero and standard deviation σ_a. The housing preference shock $z_{h,t}$ is in essence a shift in the demand for housing. It evolves according to,

$$\ln z_{h,t} = \rho_h \ln z_{h,t-1} + \varepsilon_{h,t}, \tag{2.13}$$

where $\varepsilon_{h,t}$ is an i.i.d. innovation with normal distribution mean zero and standard deviation σ_h.

2.3.8 Equilibrium

To close the model, aggregate housing is fixed and normalised to one,

$$\omega h_t + (1-\omega)h'_t = 1, \tag{2.14}$$

which is motivated by Hilber and Turner (2014) who argue that much of the mortgage interest deduction is capitalised into house prices in areas with inelastic supply of housing.[9] Equilibrium in the mortgage market requires,

$$\omega d_t + (1-\omega)m_t = 0. \tag{2.15}$$

The aggregate resource constraint is,

$$y_t = \omega c_t + (1-\omega)c'_t - \mu p_{h,t+1} h_t \int_{-\infty}^{\overline{\varphi}_{i,t+1}} \varphi \mathrm{d}F(\varphi).$$

Equilibrium definition: *A competitive equilibrium are laws of motion for* c_t, c'_t, h_t, h'_t, n_t, n'_t, d_t, m_t, $R_{d,t}$, $R_{m,t}$, r_t, T_t, $p_{h,t}$, $\overline{\varphi}_t$, y_t, $F(\overline{\varphi})$, λ_t, *satisfying the system of equations (2.1)–(2.15), the focs of firms, and the cdf* $F(\overline{\varphi}_t)$. □

2.3.9 Calibration

The calibration for a quarterly model is presented in Table 2.2.[10] The lender's discount factor is set equal to 0.99, which implies a steady state annual real interest rate of 4 percent. Borrowers are more impatient and have a discount factor of 0.97.[11] The weight of housing in the utility, η, measures the stock of housing over annual output. I set it equal to 0.05 in order to achieve a suitable steady state target. The default cost here is calibrated to 10 percent of the housing value. One could motivate this cost arising from three occurrences in housing markets. Foreclosures appear to have negative feedback effects on the values of neighbouring properties, worsening the decline in house prices (Campbell et al., 2011). A second matter is the real estate transfer tax, which a buyer incurs ipso facto

[9] This modelling approach is useful to capture the effect of the mortgage interest deduction on house prices. In a perfectly elastic environment the mortgage interest deduction will decrease the after tax cost of housing, increase housing consumption while, in equilibrium, house prices are expected to return to their pre-subsidy levels. In inelastic markets, however, the subsidy will feed into house prices and form a hurdle for constrained households. To capture this latter channel, the analysis will assume that aggregate housing is fixed in the economy.

[10] Given the stylised and minimalist nature of the model this study abstracts from estimating parameters.

[11] The patience and impatience of the agents is to some extent immaterial. What is needed to achieve equilibrium is $\gamma > \beta$. The equilibrium that will be discussed also holds for borrowers with higher discount factors, i.e. the 'more patient' impatient agents.

Table 2.2
Model calibration

Notes: All displayed values are for a quarterly calibration.

Description	Parameter	Value	Source/Target
Discount factor borrowers	β	0.97	Steady state
Discount factor lenders	γ	0.99	Steady state
Default cost	μ	0.1	Bernanke et al. (1999)
Standard deviation idiosyncratic shock	σ	0.05	Steady state
Mortgage interest deduction from taxes	τ	0.4	Marginal tax bracket
Exogenous process parameters	ρ	0.983	Kydland and Prescott (1982)
Inverse Frish elasticity of labour supply	θ	1	Uhlig (2010)
Housing preference	η	0.05	Steady state
Share of impatient agents	ω	0.2	American Housing Survey

on the privilege of transferring real property.[12] A further source of the default cost is the process of reselling, where resellers, who in case of foreclosures buy and resell houses below market value, add to the loss of the initial seller. I calibrate the mortgage interest deduction to a typical marginal tax bracket of 40 percent. In order to obtain a suitable steady state target for the default rate, the standard deviation of the idiosyncratic shock is set to 0.05. The persistence of the exogenous process parameters are set equal to 0.983 following Kydland and Prescott (1982).

2.4 Results

The model is solved using a first-order perturbation method and is subsequently simulated. Three types of simulations are discussed. First, I simulate the model with random sequences of productivity shocks and compare the business cycle statistics to those found in the data. The findings of this exercise will clarify how well the model is able to capture the empirical relationships presented earlier. Subsequently, I discuss the dynamic responses to shocks in productivity and housing preferences. These exercises will show how the economy reacts to declining housing demand and productivity. Finally, I simulate a default experiment to capture the reactions of the economy during a period of 'heightened mortgage riskiness'. In all simulations I discuss the effects of a lower mortgage interest deduction.

2.4.1 Business cycle statistics

Table 2.3 presents correlations and volatilities implied by the model. The model correctly predicts the sign of the correlations and volatilities. Quantitatively, the model comes close to correlations between house prices and mortgages found in the data but exceeds

[12] The magnitude of this tax differs nationally. In the US it ranges from as low as 0.01 percent of the total value of the transfer in some states to 4 percent in others (Federation of Tax Administrators, 2006).

those in the correlations between mortgage rates and delinquency rates. The model also predicts higher volatilities for mortgage demand, mortgage rate, and the delinquency rate than those found in the data. The findings show that although the model presented captures the essential mechanisms in the housing market, its stylised nature may not match the data completely.[13] Next, the analysis considers the effects of mortgage interest deductions.

Table 2.3
Correlations and standard deviations in the model

Notes: This table provides the average correlation and standard deviation statistics across 10 000 simulations following productivity shocks. Each simulation is for 40 years. All displayed values are for quarterly logged data. Variables are HP-detrended with smoothing parameter $81 \cdot 1e5$. Standard deviations are displayed between brackets.

	House price		**Mortgages outstanding**		**Mortgage rate**		**Delinquency rate**	
Correlations								
Mortgages outstanding	.9874	(.004)	1	(0)				
Mortgage rate	.378	(.124)	.4462	(.118)	1	(0)		
Delinquency rate	-.4265	(.086)	-.4302	(.075)	-.6744	(.0248)	1	(0)
Std dev relative to house price	1	(0)	3.9	(.194)	1.6	(.358)	15	(.117)

2.4.2 *The effects of mortgage interest deduction*

Model steady state

What is the role of mortgage interest deduction in this economy? The equilibrium is presented in Table 2.4. In the baseline economy, with a mortgage interest deduction of $\tau = 0.4$, the annual default rate is 3.7 percent. Leverage, defined as the ratio of debt to housing value, is a little over 87 percent. The quarterly mortgage interest rate paid by borrowers is 1.12 percent. The steady state effects of a lower ($\tau = 0.2$) mortgage interest deduction are presented in the last column of Table 2.4. Following a lower deduction policy, households benefit less from their tax-deductible interest payments. Their borrowing constraint becomes more binding. As a result, the demand for mortgage debt and mortgage supply show a decline. The interest rate on mortgages and house prices decline as well. The default rate on mortgages declines 2.28 percent on an annual basis. With lower tax treatment, household leverage declines. The default rate decreases since the risk that the value of the collateral in case of foreclosure will be insufficient to cover the remaining principal of the loan declines.

[13] The lack of capital investment, unemployment, labour market mobility, and nominal rigidities are some examples of the stylised nature of the model.

Table 2.4
Model steady state

Notes: All displayed values are quarterly results. The rate of default, $F(\bar{\varphi})$, is denoted annually. Baseline calibration follows Table 2.2. In the low deduction calibration τ is set to 0.2.

Description	Variable	Baseline	Low deduction
Consumption impatient households	c	.9750	.9800
Consumption patient households	c'	1.0465	1.038
Housing impatient households	h	1.0015	.9156
Housing patient households	h'	.9985	1.084
Mortgage debt	d	4.598	3.796
House price	p_h	5.240	4.788
Gross return mortgage debt	R_d	1.006	1.009
Gross return mortgage portfolio	R_m	1.010	1.010
Mortgage interest rate	r	.0112	.0108
Tax	T	.0205	.0081
Labour	n	1.026	1.020
Lagrange multiplier participation constraint	λ	17.32	22.39
Lagrange multiplier collateral constraint	λ'	.9723	.9788
Annual default probability	$F(\bar{\varphi})$	.0368	.0228
Leverage (Loan-to-value)	$d/p_h h$	.8763	.8660

Dynamic responses

Preference shock When household borrowing behaviour is influenced by fluctuations in house prices there could be real effects on the economy through consumption and mortgage defaults. To characterise the magnitude and dynamics of shocks in this economy, I simulate the effects of a decrease in housing preference in Figure 2.6.[14] I discuss two calibrations. The baseline calibration follows Table 2.2 where the mortgage interest deduction τ is set to 0.4. The baseline model responds with a decrease in non-durable consumption of borrowers. The shock decreases the borrowing capacity of constrained households and decreases the demand for mortgages. Mortgage rates increase on impact. Since borrowers have high marginal propensities to consume aggregate consumption (not plotted) rises, even though the consumption of lenders falls. The fall in house prices decreases the house value and consequently household mortgage defaults increase. The model is able to describe the dynamics observed in Figure 2.1 and is conform the cyclical properties in Figure 2.2. How come households decumulate housing services following a preference shock? Following a decline in housing preference, the households which are more credit constrained in the economy have fewer incentives to buy housing services. A unit of housing now provides fewer collateral services. In contrast, the patient households in the economy, which are not affected by a credit constraint now have more incentives to hold additional housing stock. As a result, the patient households become wealthier when house prices recover.

[14] One interpretation of a housing preference shock is that it captures the cyclical variations in the availability of resources that are needed to purchase housing services relative to non-durable goods (Iacoviello and Neri, 2010).

Figure 2.6
Responses to a housing preference shock

Notes: This figure plots the impulse responses for a decline in housing demand. Baseline calibration follows Table 2.2. In the low deduction economy there is lower mortgage interest deductibility.

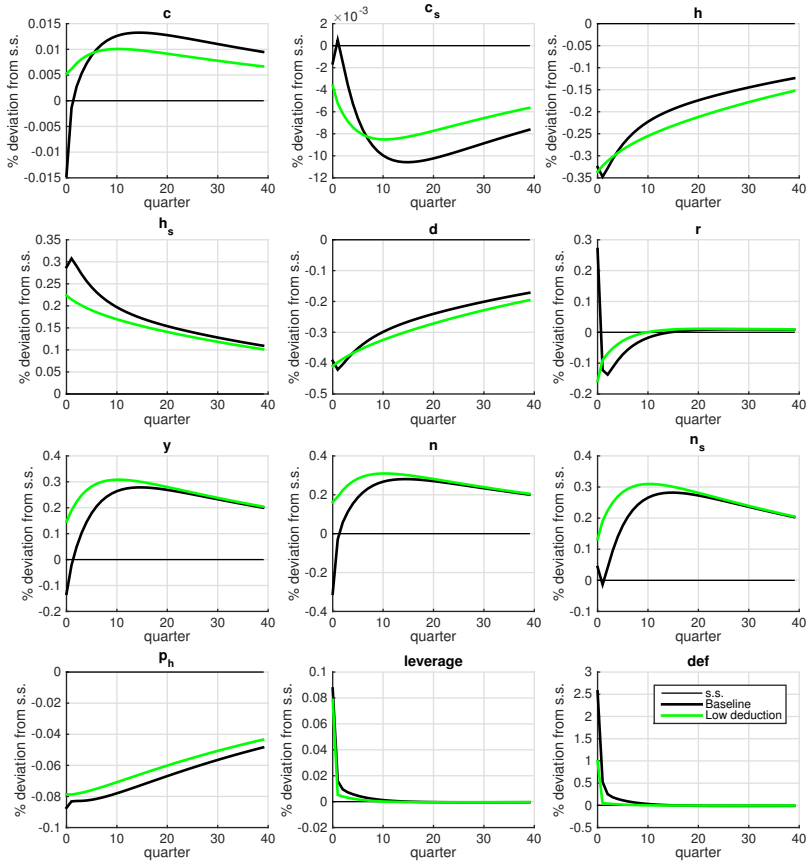
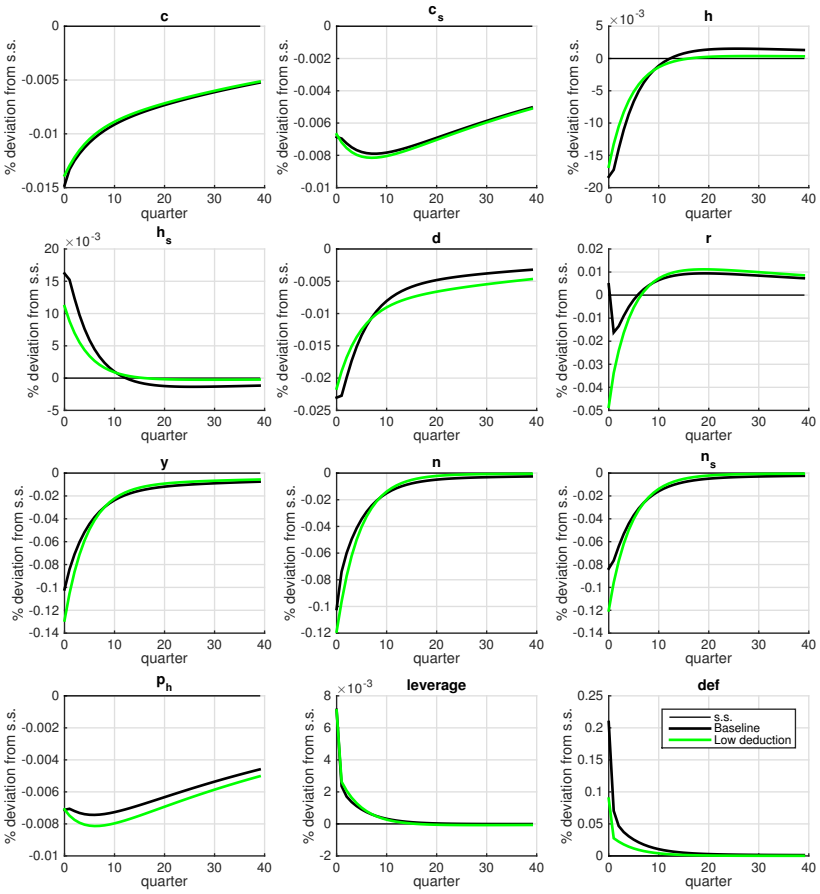


Figure 2.7
Responses to a productivity shock

Notes: This figure plots the impulse responses for a 1% decline in productivity. Baseline calibration follows Table 2.2. In the low deduction economy there is lower mortgage interest deductibility.



Now consider the low deduction calibration. Structural changes in mortgage markets that facilitate lower deduction clearly dampen the responses. Impatient households can now *increase* their non-durable consumption because a lower deduction loosens their constraint. Patient households accumulate less housing stock when the mortgage interest deduction is lower. House prices drop less compared to the situation with a higher deduction. This allows a higher fraction of the borrowers in the model to meet their payments resulting in lower default rates.

Productivity shock The dynamic responses to one-percent decline in productivity are presented in Figure 2.7. In the baseline calibration the responses show that a fall in productivity leads to a fall in household consumption for both agents. House prices drop and mortgage demand declines. This decline in the asset base and the rise in mortgage payments lead to a higher fraction of borrowers who are not able to meet their payments, thereby increasing the rate of default on impact. Impatient households decumulate housing services while patient households, which are not credit constrained, accumulate housing stock. In the second calibration, the level of deduction in the economy is lower ($\tau = 0.1$). The volatility in the response of defaults is small. Although house prices fluctuations are somewhat more responsive, the feedback effects on default rates and most of the other variables seem limited. Varying the mortgage interest deduction does not impact the dynamics of the variables following a shock to productivity.

Default experiment

This section considers the properties of the model following an increase in mortgage riskiness. I simulate the effects of an exogenous increase in the standard deviation of the idiosyncratic shock φ_t denoted σ_t. An increase in φ_t will disperse the distribution of the underlying asset. Due to a given cut-off level, an increase in σ will lead to more defaults. The default shock $z_{\sigma,t}$ enters the model through $\sigma_t = \sigma \ln z_{\sigma_t}$ and evolves according to the following law of motion,

$$\ln z_{\sigma,t} = \rho_\sigma \ln z_{\sigma,t-1} + \varepsilon_{\sigma,t}, \tag{2.16}$$

where $\varepsilon_{\sigma,t}$ is an i.i.d. innovation with normal distribution mean zero and standard deviation σ_σ.

Figure 2.8 displays the findings. In the baseline economy with $\tau = 0.4$, following a one standard deviation shock to the value of housing, house prices drop. Non-durable consumption and mortgage demand decline on impact. As previously, there is a wealth effect with impatient households decumulating housing stock as they are credit constrained. The fall in house prices leads to more delinquencies. What are the implications of a structurally lower mortgage interest deduction policy in the mortgage market? Lowering the

deductibility ($\tau = 0.1$) shows that, overall, there is much less volatility in the mortgage market. Impatient households now have fewer incentives to take on mortgage debt because their collateral constraint becomes more binding. The drop in house prices, and the associated delinquency rate, is much less on impact. From a policy perspective, the model suggests that a government's policy to loosen the borrowing constraints of households, by a higher deduction, depends also on the nature of the shocks in the economy. It seems that especially in an environment with high mortgage risk the presence of deductions leads to more volatile responses. Note that eliminating the deduction in the model will not result in an equilibrium without any defaults simply because constrained agents still have incentives to borrow due to their impatience. As the responses illustrate, the key feature of the model stems from the presence of deductions and their effects on the borrowing constraint of households.

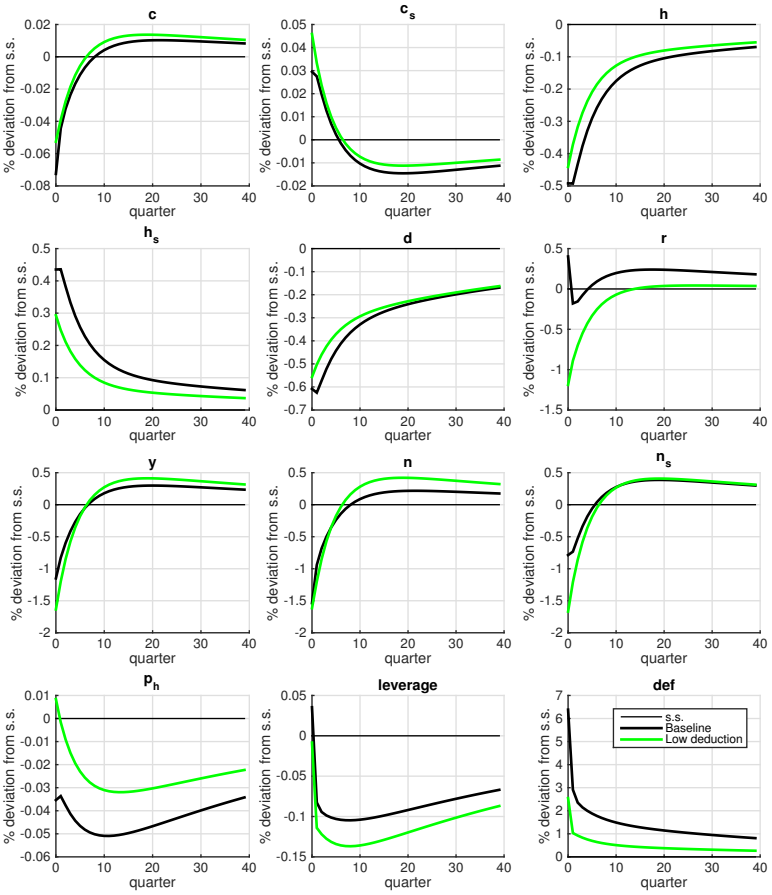
2.5 Conclusion

Understanding housing market outcomes is one of the central questions in macroeconomics. In this chapter I have developed a tractable model to analyse the macroeconomic effects of mortgage interest deductions. The model and its findings contribute to the literature in three ways. First, a higher mortgage interest deduction leads to higher house prices, more levered households, and a higher rate of mortgage default. Second, with a high mortgage interest deduction consumer spending falls more sharply. Third, when mortgage risk is high the presence of mortgage interest deduction leads to more volatile responses of the main macro-variables to exogenous shocks (i.e. preference, productivity, and mortgage riskiness shocks). Both the empirical and the theoretical evidence presented support the idea that mortgage interest deductibility may be a relevant factor in the occurrence of homeowner foreclosures and can be an important policy tool through which changes in house prices spill over to the real economy.

However, since the set-up of my model is rather basic I do not answer other questions related to the housing market. The model does not feature mobility or unemployment aspects of households in relation with the tax benefit thereby not accounting for decisions driven by these factors. Moreover, the simplicity of the model does not allow room for a discussion on the distributional effects of the mortgage interest deduction policy.

Figure 2.8
Responses to an increase in mortgage riskiness

Notes: This figure plots the impulse responses for an increase in mortgage riskiness (i.e. an increase in the standard deviation of the idiosyncratic shock). Baseline calibration follows Table 2.2. In the low deduction economy there is lower mortgage interest deductibility.



A

Supplementary derivation

The definition of the truncated normal distribution is,

$$f(x;\mu,\sigma,a,b) = \frac{\frac{1}{\sigma}\phi\left(\frac{x-\mu}{\sigma}\right)}{\Phi\left(\frac{b-\mu}{\sigma}\right)-\Phi\left(\frac{a-\mu}{\sigma}\right)},$$

where the standard normal pdf and cdf are denoted by $\phi(\cdot)$ and $\Phi(\cdot)$, respectively. Thus, if x follows a truncated normal, then the expectation of x is,

$$\begin{aligned} E(x) &= \int_a^b x f(x;\mu,\sigma,a,b)\,dx, \\ &= \int_a^b x \frac{\frac{1}{\sigma}\phi\left(\frac{x-\mu}{\sigma}\right)}{\Phi\left(\frac{b-\mu}{\sigma}\right)-\Phi\left(\frac{a-\mu}{\sigma}\right)}dx, \\ &= \frac{1}{\sigma\left(\Phi\left(\frac{b-\mu}{\sigma}\right)-\Phi\left(\frac{a-\mu}{\sigma}\right)\right)}\int_a^b x\phi\left(\frac{x-\mu}{\sigma}\right)dx. \end{aligned}$$

We also know from the properties of the truncated normal distribution that,

$$E(x) = \mu + \frac{\phi\left(\frac{a-\mu}{\sigma}\right)-\phi\left(\frac{b-\mu}{\sigma}\right)}{\Phi\left(\frac{b-\mu}{\sigma}\right)-\Phi\left(\frac{a-\mu}{\sigma}\right)}\sigma.$$

Combining the above two expressions gives,

$$\begin{aligned} \int_a^b x\phi\left(\frac{x-\mu}{\sigma}\right)dx &= \sigma\left(\Phi\left(\frac{b-\mu}{\sigma}\right)-\Phi\left(\frac{a-\mu}{\sigma}\right)\right)\mu + \sigma^2\left(\phi\left(\frac{a-\mu}{\sigma}\right)-\phi\left(\frac{b-\mu}{\sigma}\right)\right), \\ &= \sigma\left(\Phi\left(\frac{b-\mu}{\sigma}\right)-\Phi\left(\frac{a-\mu}{\sigma}\right)\right)\mu + \frac{\sigma^2}{\sqrt{2\pi}}\left(e^{-\frac{1}{2}\frac{(a-\mu)^2}{\sigma^2}}-e^{-\frac{1}{2}\frac{(b-\mu)^2}{\sigma^2}}\right). \end{aligned}$$

We are interested in,

$$\int_a^b x\frac{1}{\sigma}\phi\left(\frac{x-\mu}{\sigma}\right)dx = \left(\Phi\left(\frac{b-\mu}{\sigma}\right)-\Phi\left(\frac{a-\mu}{\sigma}\right)\right)\mu + \frac{\sigma}{\sqrt{2\pi}}\left(e^{-\frac{1}{2}\frac{(a-\mu)^2}{\sigma^2}}-e^{-\frac{1}{2}\frac{(b-\mu)^2}{\sigma^2}}\right).$$

Letting a go to minus infinity gives[15]

$$\int_{-\infty}^b x\frac{1}{\sigma}\phi\left(\frac{x-\mu}{\sigma}\right)dx = \Phi\left(\frac{b-\mu}{\sigma}\right)\mu - \frac{\sigma}{\sqrt{2\pi}}e^{-\frac{1}{2}\frac{(b-\mu)^2}{\sigma^2}}.$$

[15]From the properties of the normal distributions we know that if x follows a normal distribution with mean μ and standard deviation σ, then its pdf is given by: $\frac{1}{\sigma}\phi\left(\frac{x-\mu}{\sigma}\right)$.

Figure A2.1
Mortgage subsidy rate by state

Notes: This figure characterises the mortgage deduction subsidy rates for US states over the period 1984–2007 as calculated by the NBER TAXSIM model from micro data for a sample of US taxpayers. The subsidy for deduction items is shown as a negative tax. See Feenberg and Coutts (1993) for a description of TAXSIM.

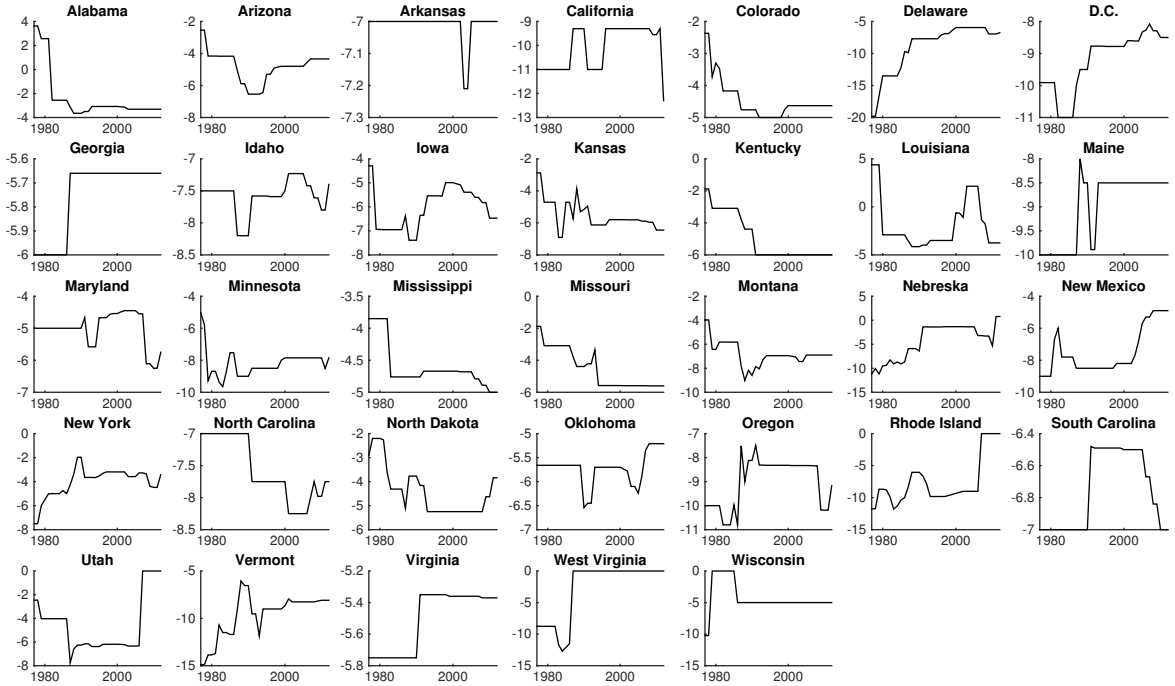


Table A2.1
Average mortgage subsidy rate by state

Notes: This table provides an overview of the NBER mortgage subsidy rate in percentages by state over the period 1984-2007. Not all states subsidise. For those that do, there is a significant variation in the subsidy rate across US states with an average subsidy rate ranging from 8.12 cents for every dollar of mortgage interest to as low as 3.28 cents.

State	MSR	Std dev	Min	Max
ALABAMA	3.56	0.12	3.29	3.72
ALASKA	0	0	0	0
ARIZONA	4.21	0.86	3.37	5.61
ARKANSAS	5.46	0.83	3.81	6.43
CALIFORNIA	6.01	0.32	5.43	6.54
COLORADO	4.71	0.27	4.44	5.28
CONNECTICUT	.06	0.07	0	0.22
DELAWARE	6.41	0.87	5.1	8.56
D.C.	8.98	0.56	7.94	10.17
FLORIDA	0	0	0	0
GEORGIA	5.32	0.11	5.21	5.56
HAWAII	8.86	0.67	7.57	9.46
IDAHO	5.74	0.37	4.96	6.56
ILLINOIS	0	0	0	0
INDIANA	0	0	0	0
IOWA	5.59	0.21	5.25	5.81
KANSAS	5.33	0.84	3.07	6.19
KENTUCKY	5.26	0.72	3.96	5.83
LOUISIANA	2.23	1.37	-1.45	3.08
MAINE	7.28	0.36	6.31	7.78
MARYLAND	3.89	1.70	0.06	4.69
MASSACHUSETTS	0	0	0	0
MICHIGAN	0	0	0	0
MINNESOTA	7.05	1.08	5.34	9.59
MISSISSIPPI	4.04	0.31	3.47	4.53
MISSOURI	4.19	0.53	3.38	4.93
MONTANA	5.25	0.86	3.56	6.19
NEBRASKA	5.02	0.52	4.17	6.3
NEVADA	0	0	0	0
NEW HAMPSHIRE	0	0	0	0
NEW JERSEY	0	0	0	0
NEW MEXICO	5.29	0.80	3.69	6.22
NEW YORK	5.73	1.21	4.44	8.49
NORTH CAROLINA	6.27	.	.	
NORTH DAKOTA	3.28	0.17	3.08	3.58
OHIO	0	0	0	0
OKLAHOMA	4.56	2.44	0.4	6.41
OREGON	8.12	0.51	6.7	8.86
PENNSYLVANIA	0	0	0	0
RHODE ISLAND	5.22	0.50	4.31	6.07
SOUTH CAROLINA	5.90	0.44	5.3	6.52
SOUTH DAKOTA	0	0	0	0
TENNESSEE	0	0	0	0
TEXAS	0	0	0	0
UTAH	6.07	0.41	5.41	7.34
VERMONT	5.72	0.70	4.4	6.76
VIRGINIA	5.29	0.12	5.15	5.49
WASHINGTON	0	0	0	0
WEST VIRGINIA	0.87	2.06	0	5.6
WISCONSIN	4.84	0.79	3.73	7.15
WYOMING	0	0	0	0

Table A2.2
Housing supply elasticities and regulation

Notes: This table provides an overview of housing supply elasticity and regulation for Metropolitan Statistical Areas in the US with population greater than 500,000. Higher figures indicate a higher degree of housing supply regulation. Housing regulation figures are retrieved from Saks (2008). Housing supply elasticities are retrieved from Saiz (2008).

MSA	Elas.	Reg.	MSA	Elas.	Reg.
Los Angeles-Long Beach, CA	0.57	1.21	Albany-Schenectady-Troy, NY	1.45	0.56
Miami, FL	0.57	0.47	Wilmington-Newark, DE-MD	1.48	
San Francisco, CA	0.59	2.1	Buffalo-Niagara Falls, NY	1.49	-1.96
New York, NY	0.64	2.21	Raleigh-Durham-Chap.H., NC	1.5	-0.14
Boston-Worcester-Lawrence, MA-NH	0.65	0.86	Stockton-Lodi, CA	1.53	
Oakland, CA	0.66	0.1	Allentown-Beth.-East., PA	1.54	-0.45
San Diego, CA	0.68	1.6	Albuquerque, NM	1.58	
Fort Lauderdale, FL	0.71	0.23	Gary, IN	1.59	1.23
Ventura, CA	0.73	1.15	Ann Arbor, MI	1.7	
Chicago, IL	0.73	-1.01	Birmingham, AL	1.79	-0.46
San Jose, CA	0.75	1.65	Las Vegas, NV-AZ	1.82	
Seattle-Bellevue-Everett, WA	0.78	1.48	Baton Rouge, LA	1.86	
Norf.-Virg.Beach-Newp.N., VA-NC	0.78		Columbus, OH	1.88	-0.07
New Orleans, LA	0.83	-0.2	Dallas, TX	1.88	-1.18
Salt Lake City-Ogden, UT	0.86	0.96	Akron, OH	1.9	
Baltimore, MD	0.86	0.8	Grand Rapids-Musk.-Hol., MI	1.93	-0.65
New H.-Brdgprt-Stmfrd-D.-W., CT	0.86	0.27	Toledo, OH	1.93	
Milwaukee-Waukesha, WI	0.86	0.19	Atlanta, GA	1.94	-0.77
Cleveland-Lorain-Elyria, OH	0.9	-0.25	Syracuse, NY	1.97	0.65
Newark, NJ	0.92	1.02	Houston, TX	2.01	-0.52
Riverside-San Bernardino, CA	0.92	1.73	Louisville, KY-IN	2.02	-0.22
Tacoma, WA	0.96		Nashville, TN	2.03	-1.65
Providence-Warw.-Pawt., RI	0.97	0.35	St. Louis, MO-IL	2.1	-0.66
West Palm Beach-Boca Raton, FL	0.99	0.51	Youngstown-Warren, OH	2.12	
Pittsburgh, PA	0.99	0.26	Cincinnati, OH-KY-IN	2.15	0.16
Sarasota-Bradenton, FL	0.99	0.08	Mobile, AL	2.16	
Portland-Vancouver, OR-WA	1.01	0.94	Richmond-Petersburg, VA	2.19	-1.23
Tucson, AZ	1.03		San Antonio, TX	2.26	-0.66
Tampa-St.Peters.-Clearw., FL	1.03	0.16	Fort Worth-Arlington, TX	2.27	
Detroit, MI	1.04	-0.69	Greensb.-Winst.-S.-H.P., NC	2.39	-0.47
Vallejo-Fairfield-Napa, CA	1.06	-0.27	Austin-San Marcos, TX	2.41	0.48
Jacksonville, FL	1.06		Columbia, SC	2.57	
Philadelphia, PA-NJ	1.1	0.47	Oklahoma City, OK	2.58	-1.32
Orlando, FL	1.15	0.5	Charlotte-Gast.-Rock H., NC-SC	2.59	-0.04
Springfield, MA	1.16		Greenvil.-Spartan.-And., SC	2.7	
Jersey City, NJ	1.16		L.Rock-N. L.Rock, AR	2.73	-0.85
Memphis, TN-AR-MS	1.17		McAllen-Edinburg-Mission, TX	2.81	
Denver, CO	1.18	-0.68	Kansas City, MO-KS	2.82	-0.95
Minneapolis-St. Paul, MN-WI	1.18	-0.16	Omaha, NE-IA	2.83	
Hartford, CT	1.19	-0.12	Dayton-Springfield, OH	2.91	-1.26
Rochester, NY	1.2	-0.68	Tulsa, OK	3.02	
Harrisburg-Lebanon-Carlisle, PA	1.27		Indianapolis, IN	3.36	-0.55
Washington, DC-MD-VA-WV	1.28	0.86	Fort Wayne, IN	5.13	
Phoenix-Mesa, AZ	1.29	-0.91	Wichita, KS	5.16	
Fresno, CA	1.31	0.2			
Colorado Springs, CO	1.31				
Bakersfield, CA	1.34				
Scranton-Wilkes-Bar.-Haz., PA	1.34				
Charleston-North Charleston, SC	1.38	1.84			
Knoxville, TN	1.42				
El Paso, TX	1.42				

Chapter 3

Banking stress test effects on returns and risks

"Mr. Smith, you're not alone in being in hock up to your ears. The whole world is in hock up to its ears."

Many banks, also heavily leveraged, were subject to regulatory scrutiny. To facilitate loan provision a "stress-test" was needed. How successful were they?

3.1 Introduction

Bank supervisors expect banks to hold sufficient capital to cover losses under adverse economic conditions. Stress testing has become an important tool for bank supervisors to achieve that goal. In stress tests the implications for individual banks' financial positions under several macroeconomic scenarios are examined, taking the banks' exposures and business models into account. Stress tests have several characteristics (Goldstein and Sapra, 2012). First, they are forward looking. Second, they generally put high weight on highly adverse scenarios, thereby providing supervisors with information about tail risks. Third, common scenarios are applied to banks so that stress tests have the ability to provide more consistent supervisory standards across banks. Finally, unlike traditional supervisory examinations that generally are kept confidential, the results of bank stress tests are frequently publicly disclosed in order to restore confidence and reduce market uncertainty (Federal Reserve, 2009b).

This chapter examines the impact of banking stress tests in the US on banks' stock prices, CDS spreads, systematic risk (proxied by banks' betas), and systemic risk over the 2009–15 period. The first test considered is the Supervisory Capital Assessment Program (SCAP) of the 19 largest Bank Holding Companies (BHCs).[1] The outcomes of this test were disclosed on May 7, 2009. Since then the Federal Reserve implemented two supervisory programs. The first program, the Comprehensive Capital Analysis and Review (CCAR), assesses the capital planning processes and capital adequacy of banks and has been conducted annually since 2011. The CCAR links quantitative stress test results with qualitative assessments of capital planning processes of banks. The second program stems from the Dodd-Frank Act and requires assessing how bank capital levels would fare in stressful scenarios (Federal Reserve, 2013b). The first Dodd-Frank Act Stress Test (DFAST) results were publicly released on March 7, 2013.

It is widely believed that stress tests conducted in the US have provided valuable information to the market. Referring to post-crisis stress tests then Federal Reserve chairman Bernanke stated:

> "Even outside of a period of crisis, the disclosure of stress test results and assessments provides valuable information to market participants and the public, enhances transparency, and promotes market discipline." (Bernanke, 2013)

Indeed, according to Morgan et al. (2014), the disclosure of the SCAP test results caused credit default swap spreads to decline and equity returns to rise. We reassess this finding and examine whether it also holds for other stress tests.

[1] We refer to BHCs as large banks. The size of the banks varies between the SCAP and subsequent stress tests. In 2009 all banks having total consolidated assets of $100 bln or more were subject to stress testing. In subsequent years the size was $50 bln or more.

Our research adds to the literature in three ways. First, we examine the effects of all post-crisis stress tests in the US. Second, in contrast to most previous research, our analysis is not confined to the effects of stress tests on equity returns and CDS spreads but also considers the impact of stress tests on bank betas. Betas capture systematic risk based on the co-movement of returns with the overall market and are therefore particularly relevant for understanding the effects of stress tests. In addition, we study whether the change in betas is due to changes in individual bank risk, or due to changes in systemic risk following the approach suggested by Nijskens and Wagner (2011). Finally, we do not only consider the impact of the publication of the stress test outcomes, but also examine other disclosure events, such as the announcement of the stress test and the disclosure of the methodology to be used, as these may also provide information (Petrella and Resti, 2013; Gick and Pausch, 2012).

As will be pointed out in more detail in Section 3.2, our paper is related to three strands of literature. The first strand examines whether information provided by the disclosure of the outcomes of stress tests reduces the opacity of banks (Morgan et al., 2014; Cardinali and Nordmark, 2011; Beltratti, 2011; Ellahie, 2012; Petrella and Resti, 2013). Most (but not all) studies conclude that stress tests produce valuable information for market participants and can play a role in mitigating bank opacity. The second strand of related literature examines to what extent supervisory information should be disclosed (e.g. Goldstein and Sapra, 2012; Schuermann, 2013). Several of these studies conclude that it may not always be optimal to fully disclose stress test results. The final related strand of literature examines how stress tests can be used to set capital ratios, limit capital distributions, and set-up resolution regimes in case of financial distress (BCBS, 2012).

Our findings suggest that the release of the 2009 stress test outcomes had no effect on equity returns in contrast with the results of Morgan et al. (2014). Our findings for post-crisis stress tests show some reaction of equity returns in some years but the effects are small and statistically weak. In addition, we find evidence that the publication of stress test results reduced CDS spreads in 2009, 2012 and 2013. We find mixed results for other dates on which stress test information was released. Our analysis of systematic risk indicates that betas were affected by the publication of the outcomes of nearly all stress tests. Moreover, we find some evidence that the decline in betas is in part driven by the correlation of the banks' stocks with the market. We interpret these findings as a decrease in systemic risk.

The paper is structured as follows. Section 3.2 provides a summary of related literature and outlines how our research is related to this literature. Section 3.3 gives an overview of the stress tests conducted in the US. Section 3.4 outlines our methodology and Section 3.5 presents our findings. Finally, Section 3.6 concludes.

3.2 Related studies and contribution

Our study is related to three strands of literature. First, several studies examine whether bank opacity differs from that of non-financial firms in 'normal' times (cf. Morgan, 2002; Flannery et al., 2004; Iannotta, 2006; Jones et al., 2012; Haggard and Howe, 2012). A good example is the recent paper by Flannery et al. (2013) who study bank equity's trading characteristics and find only limited evidence that banks are unusually opaque during normal times. From this perspective, some recent studies examine the information value of stress tests. Morgan et al. (2014) conclude that market participants correctly identified which institutions had sufficient capital under the SCAP stress test, but were surprised by how much capital was required for under-capitalized banks.

Stress tests have also been conducted by European supervisors and several recent papers examine whether the disclosure of the outcomes affected financial markets. Petrella and Resti (2013) find significant but modest market responses to the European Banking Authority (EBA) stress test in 2011. Ellahie (2012) studies equity and credit market data of Eurozone banks that took part in the stress tests in 2010 and 2011. His findings indicate that equity and bid-ask spreads were not significantly affected by stress test announcements but declined after the disclosure of stress test results. Cardinali and Nordmark (2011) report that the announcements of the stress test and the clarification of the methodology in 2010 were relatively uninformative to markets. In contrast, they find that the disclosure in 2011 by EBA of the stress test methodology was highly informative for all stress-tested banks. Likewise, Beltratti (2011) argues that the 2011 EBA stress test produced new information, as investors could not a priori distinguish between capitalized and under-capitalized banks.

Table 3.1 provides a summary of recent empirical papers on the market response to stress tests. In line with some previous papers on European stress tests, in our analysis of US stress tests we distinguish between several tests-related events, such as the announcement of the stress test and the disclosure of the methodology and the stress test outcomes. We also distinguish between banks with and banks without capital shortfalls. So our paper complements the work of Morgan et al. (2014) by documenting the effects of stress tests on equity returns and CDS spreads for stress tests conducted in the US after the SCAP.

The literature on supervisory transparency and disclosure is also closely related to our work. The central question addressed in these studies is to what extent supervisory information should be disclosed. According to Goldstein and Sapra (2012), in certain environments more disclosure is not necessarily better if one considers economic efficiency. Accordingly, the costs associated with disclosure of stress test results can be minimized in particular by disclosing aggregate, rather than bank-specific results. Also Schuermann

(2013) argues that the degree of optimal disclosure may depend on the environment. During times of crisis, the need for bank-specific disclosure is greater while during normal times the cost-benefit of stress testing disclosure may lean towards more aggregated information. Gick and Pausch (2012) argue that a supervisory authority can create value by disclosing the stress-testing methodology together with the stress test result. Bischof and Daske (2013) investigate the interaction between mandatory supervisory disclosure and voluntary disclosure strategies of banks that were subject to the EBA stress test in 2011. Their findings indicate that lower market liquidity is attributable to banks that did not voluntarily disclose their sovereign risk exposures. Banks disclosing their exposures witnessed increases in liquidity and decreases in the equity bid-ask spread.

Our work is related to this line of literature, as we do not only examine the effects of the publication of the stress test results, but also the effects of the announcement of the stress test (Petrella and Resti, 2013) and the disclosure of the methodology (Gick and Pausch, 2012).

Finally, our paper is related to the literature on the impact of regulation of Systemically Important Financial Institutions (SIFIs). Stress tests are used to set capital ratios, limit capital distributions, and set-up resolution regimes in case of financial distress (BCBS, 2012). Bongini and Nieri (2013) investigate the response of financial markets to the Financial Stability Board's publication of the list of institutions that are too-big-to-fail. They quantify the value of an implicit too-big-to-fail subsidy and find that financial markets did not strongly react to the proposed new regulation regarding SIFIs. Schaefer et al. (2013) investigate the reaction of the stock returns and CDS spreads of US and European banks to several regulatory reforms including the too-big-to-fail regulation in Switzerland. These authors report significant market reactions in response to this regulation, which strongly increased CDS spreads of systemic banks, but affected equity prices only mildly.

Our study is related to this literature as we examine the systematic risk of banks. We expect the beta of a bank to decline following the publication of the results of a stress test. The information provided by the stress tests could reduce the uncertainty on bank stability and therefore would lower the overall level of risk in the industry. This would lead to a decline in bank betas. To study the underlying shifts in systematic risk we decompose the changes in betas into changes in the correlation of stocks with the market (systemic risk) and changes in the relative variance (idiosyncratic risk) following a similar approach as Nijskens and Wagner (2011). These authors study credit risk transfers of banks through issuance of CDS and CLO contracts. They disentangle the changes in betas and find that the increase in betas was primarily due to an increase in the correlation of stocks with the market. Although banks became individually less risky using credit risk transfers, systemic risk increased. As we examine the changes in betas in a similar way we can analyse

Table 3.1
Related studies

Study	Stress test	Findings
Morgan et al. (2014)	SCAP 2009	Stress tests produce significant market reaction of stock prices. Under-capitalized banks have experienced more negative abnormal returns. CDS spreads, particularly for under-capitalized banks, decline following the release of stress test results.
Cardinali and Nordmark (2011)	EBA 2010, 2011	The 2010 EU stress test was uninformative to financial markets. The methodology release of the EBA stress test in 2011 on the other hand had a clear impact on banks. Stress tests showed no effects of GIIPS-banks being more opaque than banks from Northern Europe.
Ellahie (2012)	EBA 2010, 2011	The 2011 stress test reduced information asymmetry (i.e. equity-credit bid-ask spreads) and increased information uncertainty (measured by equity option implied volatilities and ratio of CDS spreads) of banks.
Alves et al. (2013)	EBA 2010, 2011	Both European stress tests have affected the stock prices of banks. The 2010 stress test reduced the volatility in stock prices while the volatility increased following the release of the 2011 stress test results.
Petrella and Resti (2013)	EBA 2011	Stress tests significantly affect the market and are a credible evaluation tool that reduce bank opaqueness.

how stress tests have affected systemic risk.

3.3 Stress tests in the US

The Federal Reserve's CCAR exercises conducted in 2011–15 can be classified as micro-prudential supervisory stress tests. They are 'top down' in the sense that the Fed independently produced loss estimates using its own supervisory models. Although the Fed publishes the results of stress tests, the specification of the models used to arrive at them remains a 'black box' (Bernanke, 2013). An important reason for this is to prevent the homogenization of stress test models, as banks would over time have fewer incentives to maintain independent risk management systems and adopt the specifications used by the Fed. These tests were conducted in the aftermath of the crisis and unlike the SCAP in 2009 were not crisis management stress tests. The latter differ in their emphasis on solvency, current risks, and their specific 'constrained bottom-up' approach (Oura and Schumacher, 2012). For the SCAP exercise the Fed relied more on the banks' own estimates.

Although stress tests have been criticized because of insufficient coverage or their implementation strategy, they have become an important instrument in supervisory authorities' toolkit. This is true for micro-prudential (BCBS, 2012) as well as macro-prudential

stress tests (Borio et al., 2013).[2] Table 3.2 provides a descriptive overview of the stress tests conducted in the US on which we focus. Stress test design evolved.[3] In subsequent stress tests the Fed refined the hypothetical scenarios taking into account the procyclicality of the financial system and severe adverse developments on housing, equity, and asset markets (Federal Reserve, 2012, 2013a,b).

To see how much attention stress tests received we collected news articles from a variety of news sources from the Dow Jones Factiva database for the 2009–2015 period. We searched for all news containing the words "stress test" related to the banking stress tests procedure. The number of news articles related to stress test events provides a crude indication of how much attention stress tests received. Our final list of articles contains news on individual banks, the banking industry, and the US economy. The news was filtered with all the relevant bank names and with the names of related government agencies, such as the Federal Reserve, FDIC and the US Department of the Treasury. We verified all news manually for relevance.

Our news analysis suggests that the SCAP received considerable more attention than the subsequent CCARs and DFAST. The news index also reveals that stress tests were a substantial part of market sentiment in 2009–2015. About 10 percent of all news about the US banking industry in this period relates to stress tests. Not surprisingly, the highest frequency of news reports on this topic appeared when the stress test outcomes were disclosed. Other peaks occurred when the details of the stress tests were announced and when the results for participating banks were released. In the remainder of our research, we use an event study approach to quantify the effects of the disclosure of stress test information on financial markets.

3.4 Data and methodology

3.4.1 Data

We use equity returns of banks that have participated in the US stress tests over the 2009–2015 period.[4] We employ the S&P 500 returns index as proxy for the market portfolio. Data were obtained from Bloomberg. Table 3.3 lists the participating banks considered

[2] Macro-prudential stress testing has evolved over time. This type of stress tests is discussed e.g. by Cihak (2007), Borio et al. (2013), FSA (2009), de Larosiere (2009), Sorge (2004), and Galati and Moessner (2013). Criticism raised has led to the development of new stress testing models, such as Foglia (2009), Chan-Lau (2013), Swinburne (2007), Breuer et al. (2009), Schechtman and Gaglianone (2012), and Huang et al. (2012).

[3] The design of stress tests also received attention in the literature. BCBS (2009) provides principles for sound stress testing. Greenlaw et al. (2012) propose conceptual principals for stress testing while Oura and Schumacher (2012) suggest operational principals. Spargoli et al. (2018) argues that stress tests can remove information asymmetries only if supervisory authorities implement policies to fix under-capitalized banks.

[4] We have also considered the effects of stress tests using price to book ratios as a measure of investors' beliefs in the banks' ability to generate profits. The findings from this analysis are very similar to our main results.

Table 3.2
Description of US stress tests

Notes: This table provides an overview of all stress tests conducted in US (Federal Reserve, 2009a,b, 2012, 2013b,a, 2014b,a, 2015b,a).

	Purpose/Requirements	Results
SCAP 2009	Restoring confidence, identifying future conditions for banks with insufficient capital. Banks are well-capitalized with Tier 1 capital above 6% of RWA and solvent with 4% Tier 1 common equity ratio. A total of 19 banks is assessed.	Ten banks with a capital gap. Tier 1 common capital increased to $759 bln. and Tier 1 common equity ratio increased to 10.4%.
CCAR 2011	Quantitative assessment of capital levels and qualitative assessment of internal capital planning processes of banks. Banks submit capital plans to the Fed, largest 6 banks submit trading P&L statements.	Banks mostly had to lower their capital distributions, payout decreased to 15% in 2011 from 38% in 2006.
CCAR 2012	Banks that did not participate earlier are now subject to a Capital Plan Rule. Banks submit a description of internal processes for assessing capital adequacy; policies governing capital actions; planned capital actions; and results of company-run stress tests. Banks are solvent with a 5% Tier 1 common ratio.	Four banks had a capital gap. Doubling of weighted Tier 1 common equity ratio.
DFAST 2013	Quantitatively assess how bank capital levels would fare in adverse economic conditions. Financial companies with total consolidated assets between $10 bln and $50 bln are required to conduct their own stress tests.	One bank failed to adhere to the minimum of 5% Tier 1 common equity ratio.
CCAR 2013	Quantitative and qualitative evaluation of whether a bank's capital accretion and distribution decisions are prudent. Banks have to disclose their own estimates of stressed losses and revenues. The Fed also discloses whether or not it objected to each bank's capital plan.	Two banks conditionally approved, two banks not approved.
DFAST 2014	Assessment of additional banks with $50 bln or more total consolidated assets. The Fed independently projects balance sheets and RWAs of each bank. The Basel III revised regulatory capital framework is incorporated into the assessment. A total of 30 banks is assessed.	Over the nine quarters of the planning horizon, losses at the 30 banks under the severely adverse scenario are projected to be $501 bln. One bank did not pass the assessment.
CCAR 2014	Banks with significant trading activities are required to apply a hypothetical Global Market Shock to trading and counter-party exposures. Banks are subject to a new counter-party default scenario requirement and must include losses from the default of their largest stressed counter-party. A bank's projected capital ratios are interpreted relative to the minimum capital requirements in effect for each quarter of the planning horizon.	Five banks did not pass the test.
DFAST 2015	A total of 31 banks is assessed.	All banks passed the test.
CCAR 2015	Banks were required to reflect the transition arrangements and minimum capital requirements of the revised regulatory capital framework in their estimates of pro forma capital levels and capital ratios.	Two banks did not pass.

in our research and shows the results of the stress tests.[5] We also use daily data on 5-year senior CDS spreads for a subset of the banks.[6] We employ the CDX Investment Grade Index provided by Bloomberg as proxy for a market portfolio in the CDS market. This index represents the rolling equally-weighted average of 125 of the most liquid North American CDS series with relevant rating of at least "BBB-" or "Baa3" and with 5 years maturity. In all analyses we exclude official holidays and days with limited trading.

3.4.2 *Methodology*

To examine whether stress tests have affected equity or CDS markets we follow an event study methodology described e.g. in Brown and Warner (1985), Thompson (1995), or MacKinlay (1997). Figure 3.1 provides an overview of all the relevant stress test events. Following Morgan et al. (2014), we present findings for a 3-days event window (-1,+1). Our estimation window for equity returns and CDS spreads consists of 255 trading days, i.e. the (-265,-10) time interval, where $t = 0$ is the event date of the corresponding stress test.[7] This window is sufficiently long to conduct an event study using daily data (MacKinlay, 1997). When event windows are overlapping, or a single event affects multiple banks, we can no longer assume that the abnormal returns of securities are cross-sectionally uncorrelated. Figure 3.1 shows that the date of the methodology release and the date of the disclosure of the results of the CCAR in 2012 are particularly close. In this case the covariance may deviate from zero and we can no longer use the distributional results for the aggregated abnormal returns (MacKinlay, 1997). Consequently, we treat the disclosure of the methodology and the results of CCAR 2012 as a "large" event.[8]

To measure the impact of an event we set the abnormal return of a security as the difference between the actual (ex post) return and the normal return over the relevant event window. Normal returns are estimated using the following market model,

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t} \tag{3.1}$$

where $R_{i,t}$ is the daily return of equity of bank i at time t, and $R_{m,t}$ is the return of a

[5] We include GMAC (Ally Financial) in our CDS analysis but exclude it from our stock analysis as it was not publicly traded. We also exclude MUFG Americas Holdings Corporation and Citizens Financial Group. The banks included in the stress tests cover at least 66% of total US banking sector assets.

[6] The sample for our CDS analysis is smaller as credit default swaps of some banks were not available or not traded. The following banks are included in our CDS analysis: American Express, Bank of America, Capital One Financial, Citigroup, GMAC (Ally Financial), Goldman Sachs, JPMorgan Chase, Metlife, Morgan Stanley, and Wells Fargo.

[7] We have considered different event windows: (-2,0), (0,+2), (-2,+2), (-3,0), (0,+3), (-3,+3), (-10,0), (0,+10), (-10,+3) and (-3,+10) as well as a shorter estimation window (up to 150 trading days) to avoid overlaps with events related to stress tests in other years. These findings (available upon request) are in line with our main results.

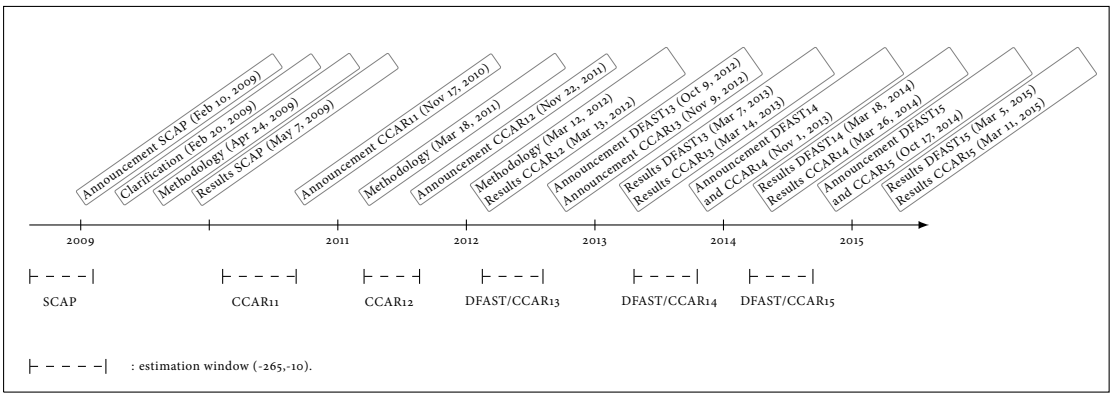
[8] In this respect our approach is similar to that of Morgan et al. (2014) who consider the clarification event of the SCAP in 2009, which actually consist of two events: Bernanke's testimony on 24 March 2009 and the release of further details about the stress test on 23 and 25 March 2009. They disentangle the effects of the events by considering how equity and bond-holders are affected. They reason that the former event mattered for both market participants but the release of the Capital Assistance Plan details mattered only for equity holders.

Table 3.3
List of the banks which passed/failed the stress tests

Notes: This table presents the list of the banks which passed/failed the 2009–2015 stress tests. '+' means that a bank passed the stress test without any frictions ('No-Gap' banks), and '-' indicates that a bank did not meet the minimum post-stress capital ratio requirements or had deficiencies in its capital planning process that undermine its overall reliability of capital planning process ('Gap' banks). An empty cell denotes that the bank did not participate in the corresponding testing procedure. The banks are divided into global SIFIs, domestic SIFIs, and non-SIFIs according to the classification of the Financial Stability Board (FSB, 2014).

Banks	2009	2012	2013		2014		2015	
Global SIFIs	SCAP	CCAR	DFAST	CCAR	DFAST	CCAR	DFAST	CCAR
Bank of America	-	+	+	+	+	+	+	+
BNY Mellon	+	+	+	+	+	+	+	+
Citigroup	-	-	+	+	+	-	+	+
Deutsche Bank							+	-
Goldman Sachs	+	+	+	-	+	+	+	+
HSBC					+	-	+	+
JPMorgan Chase	+	+	+	-	+	+	+	+
Morgan Stanley	-	+	+	+	+	+	+	+
Santander					+	-	+	-
State Street	+	+	+	+	+	+	+	+
Wells Fargo	-	+	+	+	+	+	+	+
Domestic SIFIs								
Ally Financial	-	-	-	-	+	+	+	+
American Express	+	+	+	-	+	+	+	+
BB&T	+	+	+	-	+	+	+	+
Capital One	+	+	+	+	+	+	+	+
Fifth Third Bank	-	+	+	+	+	+	+	+
PNC	-	+	+	+	+	+	+	+
Regions Financial	-	+	+	+	+	+	+	+
SunTrust Banks	-	-	+	+	+	+	+	+
U.S. Bancorp	+	+	+	+	+	+	+	+
Non-SIFIs								
BBVA Compass					+	+	+	+
BMO					+	+	+	+
Comerica					+	+	+	+
Discover					+	+	+	+
Huntington					+	+	+	+
KeyCorp	-	+	+	+	+	+	+	+
MetLife	+	-						
M&T					+	+	+	+
Northern Trust					+	+	+	+
Zions Bancorporation					-	-	+	+

Figure 3.1
Chronology of stress test events



market portfolio (the S&P 500 returns index). Similarly the CDS spread of bank i at time t is regressed on the overall index, the CDX Investment Grade Index (cf. Norden and Weber, 2004; Morgan et al., 2014). The residuals or abnormal returns (AR) implied by the market model are given by,

$$AR_{i,t} = R_{i,t} - \left(\hat{\alpha}_i + \hat{\beta}_i R_{m,t}\right) \tag{3.2}$$

where the circumflex indicates that the parameter concerned is estimated. The abnormal returns are summed over the relevant window around the event date to compute the cumulative abnormal return (CAR).[9] The t-statistics obtained from the estimation in (3.1) are adjusted for event clustering and event induced volatility following Kolari and Pynnönen (2010).[10] The adjusted t-statistics are employed to test whether the CAR significantly differs from zero.

In order to assess the possible changes in systematic risk caused by stress test events we decompose the beta into a market correlation component and a volatility component following Nijskens and Wagner (2011). We estimate the relation between returns and a banks' beta using the following model,

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \sum \delta_j D^j + \sum \beta_j D^j * R_{m,t} + \varepsilon_{i,t} \tag{3.3}$$

where α_i is the bank fixed effect, D^j is a dummy variable with value one up to ten trading days of the next event and $j \in \{A, C, M, R\}$ denote the announcement, clarification,

[9] With a slight abuse of notation, we denote the cumulative abnormal spreads obtained from the CDS counterpart of (3.1) also as CARs.

[10] In the presence of event clustering cross-correlation among securities may lead to over rejection of the null hypothesis of zero average abnormal returns. We have employed a GARCH analysis to verify that stress test events contributed to shift in volatility (not presented). Not all recent event studies adjust for clustering (e.g. Candelon and Sy, 2015), but in our view it is the proper procedure. See also Amici et al. (2013); Fratianni and Marchionne (2013); Elyasiani et al. (2014).

methodology, and result events, respectively. $D^A * R_{m,t}$, $D^M * R_{m,t}$, and $D^R * R_{m,t}$ are the interaction terms of interest. The coefficients β_j with $j \in \{A, M, R\}$, capture respectively the change in bank betas after the announcement, methodology, and result events.[11]

Next, we decompose the changes in betas into changes in the correlation of stocks with the market and changes in the relative variance. That is, the beta can be represented by,

$$\beta_i = \rho_{i,m} \frac{\sigma_i}{\sigma_m} \tag{3.4}$$

where $\rho_{i,m}$ is the correlation coefficient between the equity and the market and σ_m the variance of the market.[12] The beta in (3.4) is the product of the correlation of a bank's equity price with the market and its standard deviation relative to that of the market. We then normalize our model in (3.3) by dividing the equity and market returns by their respective standard deviations.[13] As a consequence the coefficient of the normalized returns equals the correlation of the previous series, and (3.4) changes to $\beta_i = \rho_i$. The regression equation is then changed to,

$$\tilde{R}_{i,t} = \tilde{\alpha}_i + \rho_i \tilde{R}_{m,i,t} + \sum \delta_j D^j + \sum \rho_j D^j * \tilde{R}_{m,i,t} + \varepsilon_{i,t} \tag{3.5}$$

where

$$\tilde{R}_{i,t} = \begin{array}{ll} R_{i,t}/\sigma_{i,t<t_i} & \text{if t}< t_i \\ R_{i,t}/\sigma_{i,t\geq t_i} & \text{if t}\geq t_i \end{array} \quad \text{and} \quad \tilde{R}_{m,i,t} = \begin{array}{ll} R_{m,i,t}/\sigma_{m,t<t_i} & \text{if t}< t_i \\ R_{m,i,t}/\sigma_{m,t\geq t_i} & \text{if t}\geq t_i \end{array}$$

and t_i stands for the event date. The coefficients ρ_j with $j \in \{A, M, R\}$ in Equation (3.5) capture respectively how much of the change in bank betas after the announcement, methodology, and result events are due to the market correlation component. We interpret the latter as systemic risk.

[11] Note that we exclude the clarification and methodology events of 2009 in our beta analysis as they are very close to the announcement and result release of SCAP, respectively. Similarly, we only consider the announcement of DFAST and the results release of CCAR as these are the first and last events of interest in 2013, respectively. Our post-stress-test periods for evaluating beta vary over the years.

[12] To arrive at (3.4), note that individual stock beta $\beta_i = \frac{cov_{i,m}}{\sigma_m^2}$ can be represented as $\beta_i = \rho_{i,m} \frac{\sigma_i}{\sigma_m}$ using the correlation notation $\rho_{i,m} = \frac{cov_{i,m}}{\sigma_i \sigma_m}$.

[13] To identify shifts in the relative variance, σ_i/σ_m, we do the following decomposition: $\beta^1 = \beta^0 + \Delta\beta$ where the superscripts denote the beta before and after the event. Using $\beta^1 = \rho^1_{i,m} \frac{\sigma^1_i}{\sigma^1_m} = (\rho^0_{i,m} + \Delta\rho_{i,m}) \frac{\sigma^1_i}{\sigma^1_m}$ the relative variance can be rearranged as $\frac{\sigma^1_i}{\sigma^1_m} = \frac{\beta^0 + \Delta\beta}{\rho^0_{i,m} + \Delta\rho_{i,m}}$ and, therefore, a change in relative variance is $\Delta \frac{\sigma^1_i}{\sigma^1_m} = \frac{\sigma^1_i}{\sigma^1_m} - \frac{\sigma^0_i}{\sigma^0_m} = \frac{\beta^0 + \Delta\beta}{\rho^0_{i,m} + \Delta\rho_{i,m}} - \frac{\beta 0}{\rho^0_{i,m}}$.

3.5 Results

3.5.1 How do stress tests affect equity returns and credit risk?

We present our findings in Tables 3.4 and 3.5. Table 3.4 shows reactions in the stock market and Table 3.5 shows reactions in the credit market. We discuss each market in turn, considering the announcement, clarification, methodology, and result events.

Stock market

As shown in Table 3.4, the *announcements* of stress tests generally had a mixed effect on equity returns. The stock market reacted positively to the announcement of DFAST and CCAR in 2013 but negatively in 2012. The mixed effect on stock prices may reflect that generally stress test announcements provide limited (quantitative) information on the way the stress tests will be conducted or how their results will be used.

The market's reaction to then chairman Bernanke's *clarification* in 2009 that banks would not be nationalized caused an upward movement in equity returns. The clarification event notably increased the CARs of gap banks by 31.6 percent as these banks were at the time considered to be at risk to be nationalized (Morgan et al., 2014). Similar to Morgan et al. (2014) we find no evidence that the methodology disclosure of the SCAP has led to changes in stock prices. There is some evidence that the publication of the methodology of CCAR in 2011 has affected stock prices negatively. In the other years the methodology and results were released jointly.[14]

Table 3.4 shows that, in contrast to Morgan et al. (2014), CARs of bank equity returns in 2009 were not affected after the release of stress test *results*. This holds for both gap and no-gap banks' stock prices. Our finding is different from that of Morgan et al. (2014) because our methodology accounts for event clustering (Kolari and Pynnönen, 2010).[15] Table A3.1 in the Appendix provides findings over extended event windows for the SCAP stress test. There is very little evidence of stock market reactions for the SCAP stress test except for the clarification event.

Overall the findings suggest that the release of stress test results after 2009 have had little effects on equity markets. As shown in Table 3.4 in some years stock markets reacted. In 2012, for example, for the sample of no-gap banks we find that the equity market reacted positively to the disclosure of the results of stress tests. However, the findings are statistically weak. Moreover, the magnitude of the impact in all years is lower than that in

[14] In 2012 the methodology and results were released on two consecutive days. As discussed in our methodology section we treat these events as a single 'large' event.

[15] Another difference is the estimation period. Morgan et al. (2014) estimate their analysis over a relatively less volatile period (July 1, 2006 to June 30, 2007). Our findings are robust to a change in the estimation period. Using the same estimation period as Morgan et al. (2014) and correcting for clustering, we still find that the results of the SCAP stress test did not affect stock prices within a (-1,+1) window. Results are available upon request.

2009 following chairman Bernanke's clarification. Arguably, during a crisis the need for credible information is greater than in calmer periods so the market may have valued the information disclosed in the clarification in 2009 more (Schuermann, 2013). Finally, the reactions in post-crisis stress tests are not always uniform. This is particularly so for the announcement effects (negative in 2012 and positive in 2013) but also for results (negative in 2014 and positive in 2015).

Credit market

As Table 3.5 shows, the *announcement* events had a mixed effect on CDS spreads. Spreads were negatively affected in 2009 for no-gap banks and positively in 2012 for gap banks. Moreover, we see that Bernanke's clarification of the stress test in 2009 did not affect the CDS market. This response is expected due to the structure of the CDS agreements where any change in ownership due to nationalization would not bring additional losses to contract parties.[16]

For the *methodology* events we find mixed results. For 2009 we find no impact on CDS spreads. However, in 2011 CDS spreads declined significantly following the release of the stress test methodology. This suggests that the release of the methodology in 2009 was less informative for the market compared to 2011. In 2011 there was no disclosure of stress test results, which could have led the market valuing the information provided by the methodology disclosure relatively strongly.

Table 3.5 shows a decline in the average CDS spreads in 2009 for no-gap banks following the publication of the stress test *results*. Average spreads dropped 55.43 basis points for no-gap banks. The disclosure of the results of CCAR in 2012 and 2013 also have led to lower CDS spreads. In contrast, the results of DFAST seem to have been uninformative to the credit market. The fact that CCAR in 2013 affected CDS spreads stronger than DFAST could be due to two reasons. Firstly, as Table 3.3 shows, in DFAST all the banks in our stock sample received approval while in CCAR three of these banks were not approved. The market may therefore have attached more importance to the results of CCAR. Alternatively, it could be due to the underlying assumptions of the stress tests. While DFAST was conducted conditional on no change in the capital distributions, CCAR incorporated the capital plans proposed by the banks and, therefore, may have better reflected creditworthiness (Federal Reserve, 2013a). Table A3.1 provides, again, findings over extended event windows for the SCAP stress test. The results over longer event windows are in line with our main findings for the credit market: spreads decline following the publication of stress test results.[17]

[16] Morgan et al. (2014) find a decline in CDS spreads following the clarification event (though only for gap banks). However, they consider CDS contracts with an MR document clause. This entails that these contracts do not suppose full coverage in case of a credit event. As we do not consider these types of contracts a possible nationalization would not affect the spreads.

[17] The findings over extended windows are, however, suggestive at best as the probability that other factors may affect spreads

Table 3.4
Stock market reaction to stress tests (in %)

Notes: This table presents CARs for the main stress test events over the 2009-2015 period calculated using Equation (3.2) with a (-1,+1) event window. Reported significance are based on corrected t-statistics. Column 'All' shows the effects of events on the average CARs of all banks. Columns 'No-Gap' and 'Gap' separate the effects into banks with and without capital shortfalls and/or disapproval of capital distribution plans. Column '%>0' indicates what fraction of the CARs of all banks were positive. Statistical significance is denoted as follows: *** - 1%, ** - 5%, * - 10%.

	All	%>0	No-Gap	%>0	Gap	%>0
2009						
Announcement	-.4203	44.4	-.2026	44.4	-.6378	44.4
Clarification	21.13**	100	10.66*	100	31.60**	100
Methodology	.3583	50	4.002	66.7	-3.285	33.3
Results SCAP	14.31	77.8	11.28	77.8	17.33	77.8
2011						
Announcement	-2.348	27.8				
Methodology	-1.766*	16.7				
2012						
Announcement	-.2958	44.4	-.0333	53.3	-1.609***	0
Results CCAR	2.308	88.9	2.935*	93.3	-.8292	66.7
2013						
Announcement	2.320**	94.1				
Results DFAST	1.223	88.2				
Announcement	1.586	82.4	1.626	76.9	1.404***	100
Results CCAR	.6509	70.6	.9765	76.9	-.4072	50
2014						
Announcement	-.8483	25.9	-.9805	21.7	-.0883	50
Results DFAST	.6321	70.4	.7339	73.9	.6310	100
Results CCAR	-1.212	18.5	-1.389*	13	-.1971	50
2015						
Announcement	-1.363	25	-1.355	26.9	-1.464***	0
Results DFAST	1.584	85.7				
Results CCAR	1.448*	85.7	1.606*	88.5	-.6054	50

Table 3.5
Credit market reaction to stress tests (in bp)

Notes: This table presents CARs for the main stress test events over the 2009-2015 period calculated using Equation (3.2) with an(-1,+1) event window. Reported significance are based on corrected t-statistics. Column 'All' shows the effects of events on the average CARs of all banks. Columns 'No-Gap' and 'Gap' separate the effects into banks with and without capital shortfalls and/or disapproval of capital distribution plans. Column '%>0' indicates what fraction of the CARs of all banks were positive. Statistical significance is denoted as follows: *** - 1%, ** - 5%, * - 10%.

	All	%>0	No-Gap	%>0	Gap	%>0
2009						
Announcement	-13.04	0	-10.81	0	-15.83	0
Clarification	18.65	55.6	32.15	60	1.762	50
Methodology	-11.28	33.3	-19.72	20	-.7275	50
Results SCAP	-81.70	0	-55.43**	0	-114.7	0
2011						
Announcement	3.496	60				
Methodology	-11.04**	0				
2012						
Announcement	11.64	70	9.152	57.1	17.42***	100
Results CCAR	-10.63	0	-10.54*	0	-10.84	0
2013						
Announcement	-1.459	33.3				
Results DFAST	.8788	66.7				
Announcement	-8.848	11.1	-9.394	20	-8.167	0
Results CCAR	-4.877*	0	-4.429	0	-5.438*	0
2014						
Announcement	2.369	100	2.258	100	3.251	100
Results DFAST	-.8816	33.3				
Results CCAR	.9118	66.7	.4411	62.5	4.677	100
2015						
Announcement	1.556	89.9				
Results DFAST	-.1971	44.4				
Results CCAR	.8564	89.9				

Overall, the findings indicate that stress tests in some years after the crisis have provided new information to CDS markets.

3.5.2 How do stress tests affect systematic and systemic risk?

Systematic risk

Table 3.6 presents event dummies associated with the stress tests and the interaction terms with betas. We focus our discussion on these interaction terms. Table 3.6 shows that the impact of the *announcement* effects are mixed. In 2009 the announcement of SCAP has led to an increase in systematic risk. For the remaining years there is no consistent evidence of movement in betas. Considering *results* events, in 2009 the betas were reduced following the publication of the results of the SCAP. Specifically, we find a strong decline in systematic risk (-.2305) after the publication of results. Similarly, the beta of banks declined after the release of stress test results in 2013 (-.2174). These findings suggest that market participants expected stress test results to be worse than they ex-post turned out to be and as a consequence betas declined in 2009 and 2013.

Systemic risk

Table 3.7 presents the estimation results for our standardized model (Equation (3.5)). We are interested in the coefficients of the interaction terms, denoted by ρ. Following Nijskens and Wagner (2011), we interpret a decline in the correlation component as a decline in systemic risk. Except from a weak effect in 2012, we see no evidence that the *announcement* events affected systemic risk of banks. However, the *methodology* release in 2011 increased ρ and contributed to the increase in beta reported in Table 3.6. For *results* events there is a decrease in the correlation of the stock series with the market in 2009 and 2012, suggesting that systemic risk declined.[18]

Gap vs no-gap banks

To examine whether systematic and systemic risk of gap and no-gap banks were affected differently, we re-estimate Equations (3.3) and (3.5) for no-gap banks and gap banks. The resulting regressions are shown in, respectively, Table 3.8 and Table 3.9. In what follows we focus our discussion on the beta effects associated with the results events.

Considering the first two columns, we see that the decrease in the beta in 2009 as reported in Table 3.6 was due to the effects on no-gap banks. The results of SCAP seem to have caused a significant decrease in betas of no-gap banks while the betas of gap

increases as the event window is extended.

[18] We attribute the insignificance of the corresponding beta for CCAR 2012 in Table 3.6 to the relative variance component, which may have added sufficient noise to make the overall change in beta insignificant.

Table 3.6
Systematic risk

Notes: This table presents the estimation results to Equation (3.3) over the period 2009–2014. Robust standard errors in parentheses. Statistical significance is denoted as follows: *** - 1%, ** - 5%, * - 10%.

	2009	2011	2012	2013	2014
Market β	1.792***	1.426***	1.566***	1.442***	1.196***
	(.0625)	(.0564)	(.0424)	(.0591)	(.0485)
Announcement dummy	.0001	.0012	.0012	-.0000	.0004
	(.0038)	(.0013)	(.0013)	(.0008)	(.0006)
Result dummy	-.0018	-.0003	.0009	.0001	-.0004
	(.0023)	(.0010)	(.0010)	(.0007)	(.0005)
Announcement β effect	.9535***	.0493	.1309	-.1211	.0304
	(.1491)	(.1420)	(.1173)	(.0978)	(.0817)
Methodology β effect		.1269*			
		(.0723)			
Result β effect	-.2305*		-.0927	-.2174**	-.0562
	(.1267)		(.0995)	(.0873)	(.0867)
Constant	-.0001	-.0027**	-.0022**	-.0003	.0000
	(.0024)	(.0011)	(.0013)	(.0008)	(.0006)
Number of id	18	18	18	17	28
Trading days	597	406	371	445	367
R^2	.4720	.6260	.6392	.4881	.4456

Table 3.7
Systemic risk

Notes: This table presents the estimation results to Equation (3.5) over the period 2009–2014. Robust standard errors in parentheses. Statistical significance is denoted as follows: *** - 1%, ** - 5%, * - 10%.

	2009	2011	2012	2013	2014
Market ρ	.7409***	.7616***	.8589***	.7413***	.6881***
	(.0331)	(.0291)	(.0278)	(.0339)	(.0303)
Announcement dummy	-.0100	.0477	.0269	-.0110	.0396
	(.0664)	(.0512)	(.0523)	(.0524)	(.0489)
Result dummy	-.0580	.0056	.0186	.0015	-.0339
	(.0404)	(.0415)	(.0420)	(.0464)	(.0461)
Announcement ρ effect	.0595	-.0756	-.0897*	-.0583	.0076
	(.0670)	(.0518)	(.0520)	(.0526)	(.0487)
Methodology ρ effect		.0860**			
		(.0415)			
Result ρ effect	-.0706*		-.1296***	-.0313	-.0547
	(.0398)		(.0421)	(.0466)	(.0462)
Constant	-.0002	-.1001***	-.0515	-.0057	.0060
	(.0405)	(.0387)	(.0408)	(.0456)	(.0460)
Number of id	18	18	18	17	28
Trading days	597	406	371	445	367
R^2	.4902	.6156	.6391	.5093	.4526

Table 3.8
Systematic risk gap and no-gap banks

Notes: This table presents the estimation results to Equation (3.3) over the period 2009–2014. Columns 'No-Gap' and 'Gap' separate the effects into banks with and without capital shortfalls and/or disapproval of capital distribution plans. Robust standard errors in parentheses. Statistical significance is denoted as follows: *** - 1%, ** - 5%, * - 10%.

	2009		2012		2013		2014	
	No-gap	Gap	No-gap	Gap	No-gap	Gap	No-gap	Gap
Market β	1.774***	1.744***	1.575***	1.542***	1.415***	1.372***	1.184***	1.184***
	(.0574)	(.0552)	(.0411)	(.0384)	(.0502)	(.0442)	(.0459)	(.0407)
Announcement dummy	.0008	.0011	.0010	.0012	-.0000	-.0000	.0004	.0006
	(.0036)	(.0035)	(.0013)	(.0013)	(.0001)	(.0007)	(.0006)	(.0005)
Result no-gap dummy	-.0020		.0009		.0002		-.0005	
	(.0017)		(.0010)		(.0007)		(.0006)	
Result gap dummy		-.0011		.0005		-.0001		.0003
		(.0028)		(.0009)		(.0006)		(.0006)
Announcement β effect	.9726***	1.002***	.1225	.1553	-.0674	-.0244	.0406	.0406
	(.1470)	(.1464)	(.1169)	(.1162)	(.0918)	(.0890)	(.0802)	(.0774)
Result no-gap β effect	-.3160***		-.1647*		-.1700**		-.0278	
	(.0923)		(.0950)		(.0775)		(.0845)	
Result gap β effect		-.0767		.2494**		-.1682***		-.1560*
		(.1480)		(.1189)		(.0646)		(.0889)
Constant	-.0014	-.0008	-.0021	-.0021	.0002	.0003	.0001	-.0002
	(.0019)	(.0026)	(.0013)	(.0013)	(.0008)	(.0008)	(.0006)	(.0006)
R^2	.4721	.4710	.6390	.6388	.4915	.4907	.4455	.4454
Number of id	18		18		17		28	
Trading days	597		371		394		367	

Table 3.9
Systemic risk gap and no-gap banks

Notes: This table presents the estimation results to Equation (3.5) over the period 2009–2014. Columns 'No-Gap' and 'Gap' separate the effects into banks with and without capital shortfalls and/or disapproval of capital distribution plans. Robust standard errors in parentheses. Statistical significance is denoted as follows: *** - 1%, ** - 5%, * - 10%.

	2009		2012		2013		2014	
	No-gap	Gap	No-gap	Gap	No-gap	Gap	No-gap	Gap
Market β	.6845***	.7207***	.8474***	.8061***	.7399***	.7250***	.6735***	.6728***
	(.0208)	(.0194)	(.0250)	(.0213)	(.0276)	(.0234)	(.0276)	(.0234)
Announcement dummy	.0155	.0141	.0248	.0238	-.0084	-.0155	.0372	.0561
	(.0624)	(.0616)	(.0512)	(.0495)	(.0489)	(.0461)	(.0477)	(.0452)
Result no-gap dummy	-.0497		.0150		.0125		-.0462	
	(.0365)		(.0416)		(.0450)		(.0473)	
Result gap dummy		-.0492		.0353		-.0219		.0339
		(.0428)		(.0457)		(.0445)		(.0480)
Announcement β effect	.0623	.0261	-.0782	-.0369	-.0487	-.0339	.0222	.0230
	(.0621)	(.0615)	(.0506)	(.0493)	(.0480)	(.0458)	(.0471)	(.0448)
Result no-gap β effect	.0204		-.1236***		-.0371		-.0243	
	(.0217)		(.0381)		(.0387)		(.0442)	
Result gap β effect		-.0846***		-.0493		-.0021		-.1346
		(.0246)		(.0344)		(.0325)		(.0390)
Constant	-.0404	-.0067	-.0499	-.0464	.0074	.0133	-.0014	-.0218
	(.0294)	(.0407)	(.0404)	(.0364)	(.0444)	(.0385)	(.0459)	(.0418)
R^2	.4892	.4906	.6386	.6359	.5122	.5199	.4522	.4525
Number of id	18		18		17		28	
Trading days	597		371		394		367	

banks were not affected. This finding complements the findings of Morgan et al. (2014) who show that market participants' ex ante expectations of capital shortfalls were worse than they ex post turned out to be. Earlier we reported that the results of CCAR in 2012 did not affect the betas. It turns out that the publication of the CCAR 2012 result did affect the betas of gap banks (.2284). In 2013, there is a large change in the overall beta following the results of CCAR for both gap (-.2617) and no-gap (-.2110) banks. Overall there is strong evidence of a decline in systematic risk following stress test results in most years.

Table 3.8 also shows that the changes in betas of gap banks significantly differ from changes in betas of no-gap banks in 2012. As revealed by the stress test results, most banks had sufficient capital to maintain their operations under the adverse economic scenario employed, but some banks appeared to be under-capitalized. The signs of betas in 2012 associated with stress test results for gap and no-gap banks suggest that the betas move in opposite directions.

Considering systemic risk for gap banks, Table 3.9 suggests that the publication of the stress test results affected systemic risk also in 2009 and 2012. The release of stress test results in 2009 decreased the beta of gap banks (-.0846) while the release of results in 2012 lowered the systemic risk component of the beta (-.1236).

3.6 Conclusion

As stress tests are an important tool for banking supervisors, it is important to consider their effects on stock and credit markets. We have quantified the market reactions of US stress tests performed after the start of the financial crisis by considering their effects on stock returns, CDS spreads, systematic risk, and systemic risk. Considering stock markets, our findings indicate that the publication of stress test results had little effect on stock returns. The clarification event in 2009 by then Fed chairman Bernanke and the results of CCAR in 2012 did affect stock markets positively. Considering credit markets, our findings show evidence of a decline in CDS spreads following the release of the stress test results in 2009, 2012, and 2013.

We conclude that the release of information about stress tests did occasionally move markets. In other words, stress tests may have provided information to markets. Moreover, the value attached to the information may have been depending on other factors such as the state of financial circumstances during the publication of the results.

Our analysis of banks' betas suggests that the publication of stress test results has affected banks' systematic risk in 2009 and 2013. Studying the changes in betas we find that stress tests reduced systemic risk in 2009 and 2012. Overall, we conclude that stress tests have produced valuable information for market participants and can play a role in

mitigating bank opacity. So, our findings suggest that stress tests are a useful tool in mitigating systematic and systemic risk in stock and credit markets.

A

Table A3.1
Market reactions to the 2009 SCAP stress test over extended windows

Notes: This table presents CARs for the 2009 SCAP stress test calculated using Equation (3.1) over extended event windows. The final rows of the announcement and methodology sections in the table do not extend to +10 trading days due the occurrence of respectively the clarification and results events. Column 'All' shows the effects of events on the average CARs of all banks. Columns 'No-Gap' and 'Gap' separate the effects into banks with and without capital shortfalls and/or disapproval of capital distribution plans. Reported significance is based on corrected t-statistics. Statistical significance is denoted *** - 1% ** - 5%, * - 10%.

Event window	All	No-Gap	Gap	All	No-Gap	Gap
	Stock market (in %)			Credit market (in bp)		
Announcement						
(0)	-8.602	-4.016*	-13.19	-4.615	-5.069	-4.049
(-1,+1)	-.4203	-.2027	-.6378	-13.04	-10.81	-15.83
(-1,0)	-5.682	-3.327*	-8.038	-16.15*	-15.06**	-17.52
(0,+1)	-3.340	-.8917	-5.788	-1.507	-.8228	-2.363
(-2,+2)	4.709	-1.650	11.07	-26.87**	-21.41***	-33.69*
(-2,0)	2.728	-1.117	6.627	-26.40**	-21.16***	-32.96*
(0,+2)	-6.621	-4.495	-8.747	-5.082	-5.319	-4.785
(-3,+3)	2.050	-4.256	8.357	-28.76*	-30.89***	-26.10
(-3,0)	3.303	-.9386	7.544	-32.05**	-31.34***	-32.93
(0,+3)	-9.854	-7.333	-12.38	-1.325	-4.617	2.790
(-10,+3)	-1.726	1.386	4.838	-45.37*	-53.99***	-34.60
(-10,0)	-.4734	4.703	-5.650	-48.66**	-54.44***	-41.44
Clarification						
(0)	8.750***	.7.335***	10.17***	10.51	15.42	4.372
(-1,+1)	21.13**	10.66*	31.60**	18.65	32.15	1.762
(-1,0)	15.32***	9.637***	21.01***	20.44	21.15	19.54
(0,+1)	14.56*	8.361*	20.75**	8.721	26.42	-13.41
(-2,+2)	29.37*	19.84*	38.91*	37.51	52.81	18.39
(-2,0)	15.87**	11.97**	19.76**	47.68*	40.97**	56.08
(0,+2)	22.26*	15.20	29.31*	.3420	27.26	-33.31
(-3,+3)	14.97	12.90	17.05	48.02	72.14	17.87
(-3,0)	9.403	8.109	10.70	64.14*	52.65*	78.50
(0,+3)	14.32	12.13	16.51	-5.610	34.91	-56.26
(-3,+10)	12.79	4.756	20.82	178.0	217.7*	128.4*
(0,+10)	12.14	3.981	20.29	124.4	180.4	54.31
Methodology						
(0)	1.244	2.324	.1649	-9.797	-11.34	-7.862
(-1,+1)	.3583	4.002	-3.285	-11.28	-19.72	-.7275
(-1,0)	3.922	7.018	.8250	-2.956	-5.241	-.1009
(0,+1)	-2.319	-.6926	-3.945	-18.12	-25.83	-8.488
(-2,+2)	-5.445	-.3120	-10.58	1.302	-12.67	18.77
(-2,0)	.1950	4.081	-3.691	5.265	4.514	6.205
(0,+2)	-4.396	-2.069	-6.722	-13.76	-28.53	4.699
(-3,+3)	.8916	7.978	-6.195	19.28	.1463	43.20
(-3,0)	4.675	9.999	-.6495	22.52	20.11	25.54
(0,+3)	-2.539	.3024	-5.380	-13.04	-31.31	9.803
(-10,+3)	8.398	11.29	5.507	-62.80	-89.86	-28.96
(-10,0)	11.72	12.94	10.49	-58.70	-69.96	-44.64
Result						
(0)	-1.213	-.4244	-2.001	-34.68*	-27.47	-43.70**
(-1,+1)	14.31	11.28	17.33	-81.76	-55.43**	-114.7
(-1,0)	6.536	5.724	7.347	-64.06	-44.26**	-88.82
(0,+1)	6.559	5.136	7.982	-52.38	-38.63**	-69.56*
(-2,+2)	8.067	3.270	12.86	-93.79	-61.38**	-134.3*
(-2,0)	5.171	3.456	6.883	-65.59	-45.43**	-90.79*
(0,+2)	1.683	-.6141	3.981	-62.88	-43.41**	-87.21*
(-3,+3)	11.99	5.093	18.90	-82.49	-53.12**	-119.2
(-3,0)	12.85	8.043	17.66	-58.69	-38.91	-83.42*
(0,+3)	-2.067	-3.374	-.7587	-58.48	-41.67*	-79.49
(-3,+10)	11.21	6.451	15.97	-116.3***	-94.19***	-144.0***
(0,+10)	-2.855	-2.017	-3.693	-92.33***	-82.74**	-104.3***

Chapter 4

Market reactions to the ECB's Comprehensive Assessment

An extended regulatory assessment—deemed to be necessary—was conducted for Eurozone banks as well by the European Central Bank.

4.1 Introduction

On 26 October 2014 the European Central Bank (ECB) published the outcomes of the so-called Comprehensive Assessment of banks in the euro area (and Lithuania). A year before, on 23 October 2013, the ECB had announced the assessment in preparation for its new task as banking supervisor in the euro area. The Comprehensive Assessment consisted of an Asset Quality Review (AQR) and a stress test. Its aim was to scour banks' books for hidden problems, test their ability to withstand crises, and force weak banks to raise more capital. The ECB hopes that the AQR and the stress test will clear up lingering doubts about the health of banks in the euro area, so that banks can raise funds more easily and increase lending. As ECB President Mario Draghi put it: "We expect that this assessment will strengthen private sector confidence in the soundness of euro area banks and in the quality of their balance sheets."[1] Arguably, previous stress tests in the euro area failed to restore confidence because some banks that passed them soon thereafter collapsed (Ewing, 2014).[2]

In stress tests the implications for individual banks' financial positions under several macroeconomic scenarios are examined, taking the banks' exposures and business models into account. These tests are run by all banks involved based on common scenarios and an identical forecast window making results highly comparable across banks (Petrella and Resti, 2013).

Some previous studies examined the impact of EBA stress tests on financial markets. Using a similar event study approach as the current paper, Petrella and Resti (2013) find significant market responses to the EBA stress test in 2011. They conclude that stress tests produce valuable information for market participants and can play a role in mitigating bank opacity. Ellahie (2012) studies equity and credit market data of Eurozone banks that took part in the stress tests in 2010 and 2011. His findings indicate that information asymmetry and information uncertainty measures were not significantly affected by stress test announcements but that information asymmetry declined after the disclosure of the 2011 stress test results, while information uncertainty increased. Cardinali and Nordmark (2011) report that the announcements of the stress test and the clarification of the methodology in 2010 were relatively uninformative to markets. In contrast, they find that the disclosure in 2011 by EBA of the stress test methodology was highly informative for all stress-tested banks. Likewise, Beltratti (2011) argues that the 2011 EBA stress test produced new information, as investors could not a priori distinguish between capitalized and under-capitalized banks. Finally, Candelon and Sy (2015) compare the market

[1] Source: http://www.ecb.europa.eu/press/pr/date/2013/html/pr131023.en.html.

[2] As pointed out by Goldstein (2014), after the 2011 EU-wide stress test performed by the European Banking Authority (EBA), Irish Life and Permanent had to be placed in a government-restructuring program even though it had a very high risk-based ratio in the test. Likewise, Dexia (a French-Belgian bank) and Bankia (based in Spain) also passed the 2011 test but soon thereafter required a taxpayer-financed bailout.

impact of all US and EU-wide stress tests performed from 2009 to 2013. They find that the 2011 EU exercise is the only EU-wide stress test that resulted in a significant negative market reaction.[3]

This chapter examines the impact of the announcement of the Comprehensive Assessment and the publication of its outcomes on banks' stock prices and CDS spreads. Our results suggest that stock prices and CDS spreads generally did not react to the publication of the results. This conclusion also holds for banks with a capital shortfall. Only for banks in some countries do we find weak evidence for (mixed) effects on stock prices, while CDS spreads for German banks declined.

The chapter is structured as follows. Section 4.2 outlines the Comprehensive Assessment. Section 4.3 describes our methodology and Section 4.4 presents the results. Section 4.5 offers our conclusions.

4.2 The Comprehensive Assessment

In the first phase of the assessment, the Asset Quality Review, teams of examiners pored over the books of the 130 most important banks in the euro area, covering approximately 82 percent of total bank assets (Ewing, 2014). The aim of the review was to uncover hidden problems, such as bad loans that banks had not disclosed. The AQR conducted by the ECB and national competent authorities (NCAs) examined whether assets were properly valued on banks' balance sheets as on 31 December 2013. It made banks comparable across national borders by applying common definitions for previously diverging concepts and a uniform methodology when assessing balance sheets.

In the second phase of the assessment, banks were subjected to a stress test intended to measure banks' ability to withstand a crisis, such as a severe recession or turmoil in global financial markets (Ewing, 2014). The stress test used both a baseline and an adverse scenario for testing banks' resilience to stress. In the baseline scenario, the EU economy develops in line with the European Commission's economic projections up to 2016; in the adverse scenario, macroeconomic developments clearly deteriorate. Banks were required to maintain a minimum CET1 ratio of 8 percent under the baseline scenario (as for the AQR) and a minimum CET1 ratio of 5.5 percent under the adverse scenario.

The AQR showed that as of end-2013 the carrying values–or book values–of banks' assets need to be adjusted by €48 billion, which will be reflected in the banks' accounts or prudential requirements. Furthermore, using a standard definition for non-performing exposures (any obligations that are 90 days overdue, or that are impaired or in default), the review found that banks' non-performing exposures increased by €136 billion to a total of €879 billion. The assessment found a capital shortfall of almost €25 billion at

[3] Examples of more recent studies are e.g. Carboni et al. (2017) and Barucci et al. (2018).

25 (mainly small and medium-sized) banks (see Table 4.1). Most of these banks were located in Southern Europe: nine banks are Italian, while three banks come from Cyprus and Greece, two from Belgium and Slovenia, and one from Austria, France, Germany, Ireland, Portugal, and Spain. Twelve of the 25 banks covered their capital shortfall by increasing capital by €15 billion in 2014. The Comprehensive Assessment also showed that a severe scenario would deplete the banks' top-quality, loss-absorbing Common Equity Tier 1 (CET 1) capital by about €263 billion. This would result in the banks' median CET1 ratio decreasing by 4 percentage points from 12.4 to 8.3 percent.[4]

Most market participants consider the Comprehensive Assessment much more credible than previous EBA stress tests, but some academics are critical. According to de Groen (2014), one weakness of the Comprehensive Assessment is that the ECB focused purely on the CET1 ratio, which is based on risk-weighted assets. de Groen has calculated capital shortfalls under several alternative criteria, one of them being the leverage ratio. His calculations suggest that 34 banks would require almost €21 billion in total to meet the threshold of 3 percent minimum leverage ratio under the adverse scenario. According to the results of de Groen (2014), several underperforming banks have their headquarters in northern Europe, with five banks based in Germany, four banks each in Belgium and France, and three banks in the Netherlands failing to meet the threshold under the adverse scenario. Likewise, in their stress test Acharya and Steffen (2014a,b) report much higher capital shortfalls than the ECB. Acharya and Steffen (2014b) conclude that the "regulatory stress test outcomes are potentially heavily affected by the discretion of national regulators in measuring what is 'capital', and especially by the use of risk-weighted assets in calculating the prudential capital requirement. This highlights the importance of using multiple benchmark leverage ratios, such as the market-based approach we employ, and simple leverage ratio (which is not affected by regulatory risk weights)."

[4]Capital shortfalls should be covered within six months for those identified in the AQR or the baseline stress test scenario, and within nine months for those identified in the adverse stress test scenario. Shortfalls revealed by the AQR and the baseline stress test scenario may only be covered by Common Equity Tier 1 (CET1) capital instruments. The use of Additional Tier 1 (AT1) capital instruments to cover shortfalls arising from the adverse stress test scenario is limited, depending on the trigger point of conversion or write-down.

Table 4.1
List of Banks in the Comprehensive Assessment

Notes: This table shows the list of banks in our analysis as well as the subset of banks that did not pass the Comprehensive Assessment. The columns "Stock data" and "Spread data" indicate whether listed banks had respectively stock or CDS data available. "Shortfall" denotes the size of the capital gap the banks have (in billion €). "Post-shortfall" denotes banks that still have to cover their capital shortfall (also in billion €) after the release of stress test results.

Country	Bank	Stock data	Spread data	Shortfall	Post-shortfall
AT	Erste Group Bank	+	-		
AT	Osterreichische Volksbanken	-	-	.86	.86
BE	AXA Bank Europa	-	+	.20	.07
BE	Dexia	+	-	.34	.34
BE	KBC Group	+	-		
CY	Bank of Cyprus Public Co.	-	-	.92	
CY	Co-operative Central Bank	-	-	1.17	
CY	Hellenic Bank Public Co.	+	-	.28	.18
DE	Aareal Bank	+	-		
DE	Commerzbank	+	+		
DE	Deutsche Bank	+	+		
DE	IKB Deutsche Industriebank	+	-		
DE	Munchener Hypothekenbank	-	-	.23	
DE	Volkswagen Fin. Serv.	-	+		
EE	AS SEB Pank	-	+		
ES	Banco Bilbao Vizcaya Argentaria	+	-		
ES	Banco de Sabadell	+	+		
ES	Banco Popular Espanol	+	-		
ES	Banco Santander	+	-		
ES	Bankinter	-	+		
FR	BNP Paribas	+	+		
FR	C.R.H. Caisse de Ref. de lfbHabitat	-	-	.00	
FR	HSBC France	-	+		
FR	Societe General	+	+		
GR	Alpha bank	+	-		
GR	Eurobank Ergasias	+	-	4.63	1.76
GR	National Bank of Greece	+	-	3.43	.93
GR	Piraeus Bank	+	-	.66	
IE	Allied Irish Banks	+	-		
IE	Permanent tsb	-	-	.85	.85
IE	Gov. Comp. Bank of Ireland	+	-		
IE	Ulster Bank Ireland	-	+		
IT	Banca Carige	+	-	1.83	.81
IT	Banca Monte dei Paschi di Sienna	+	-	4.25	2.11
IT	Banca Piccolo Credito Valtellinese	+	-	.38	
IT	Banca Popolare dell'Emilia Rom.	+	-	.13	
IT	Banca Popolare di Milano	+	+	.68	.17
IT	Banca Popolare di Sondrio	+	-	.32	
IT	Banca Popolare di Vicenza	-	-	.68	.22
IT	Banco Popolare S.C.	+	+	.43	
IT	Credito Emiliano	+	-		
IT	Intesa Sanpaolo	+	+		
IT	Mediobanca	+	+		
IT	UniCredit	+	+		

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Country	Bank	Stock data	Spread data	Shortfall	Post-shortfall
IT	Unione di Banche Italiane S.C.	+	-		
IT	Veneto Banca	-	-	.71	
LU	UBS Luxembourg	-	+		
MT	Bank of Valletta	+	-		
MT	HSBC Bank Malta	+	-		
NL	ING Bank	-	+		
NL	Nederlandse Waterschapsbank	-	+		
PT	Banco BPI	+	-		
PT	Banco Comercial Portugues	+	-	1.14	1.15
PT	Caixa Geral de Depositos	-	+		
SI	Nova Kreditna Banka Maribor	-	-	.03	.03
SI	Nova Ljubljanska banka	-	-	.03	.03
SK	Vseobecna uverova banka	+	-		
Total				24.19	9.52

4.3 Method

We use equity returns and CDS spreads of banks that have participated in the Comprehensive Assessment. Not all banks are listed. Likewise, for some banks CDS are not available. Table 4.1 indicates which banks are taken into account in our analysis.[5] Data were obtained from Bloomberg.

Before the ECB announced the outcomes of the Comprehensive Assessment several estimates of capital shortages of European banks were published. Acharya and Steffen (2014a), for example, find an EU-wide capital shortfall of hundreds of billions of euros. In their estimates, the largest part of that aggregate shortfall resides with large French banks. If such expectations had been priced in, the publication of the outcomes of the Comprehensive Assessment, which suggested much lower capital shortfalls, may have surprised financial markets.

To examine whether stress tests have caused abnormal movements in equity or CDS markets we follow previous studies, such as Petrella and Resti (2013) and Morgan et al. (2014), and use an event study methodology. To measure the impact of an event we set the abnormal return of a security as the difference between the actual (ex post) return and the normal return over the relevant event window. Normal returns are estimated using the following market model:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t} \tag{4.1}$$

where $R_{i,t}$ is the daily return of equity of bank i at time t, and $R_{m,t}$ is the return of a

[5] Our analysis does not consider the effects on banks that were not part of the assessment. The Comprehensive Assessment covers 82% of total banking assets in the Euro Area making it exceedingly difficult to have a proper control sample in our analysis.

market portfolio. We use the MSCI Europe Index as proxy for the market portfolio.[6] In addition, we employ daily data on 5-year senior CDS spreads for a subset of the banks. We regress the CDS spread of bank i at time t on the overall index and employ the iTraxx Europe Index provided by Bloomberg as proxy for a market portfolio in the CDS market.

The residuals or abnormal returns (AR) implied by the market model are given by:

$$AR_{i,t} = R_{i,t} - (\hat{\alpha}_i + \hat{\beta}_i R_{m,t}) \tag{4.2}$$

where the circumflex indicates that the parameter concerned is estimated. Next, following Morgan et al. (2014), we sum the abnormal returns over the relevant window around the event date (T) to compute the cumulative abnormal return (CAR). While we experimented with windows of various sizes, we follow Morgan et al. (2014) and focus on a 3-day window (-1,+1).[7] Our estimation windows for equity returns and CDS spreads consists of 255 trading days, i.e. the (-265,-10) time interval, where $T = 0$ is the event date (i.e. the announcement of the assessment or the publication of the outcomes). This window is sufficient to conduct an event study using daily data (MacKinlay, 1997). The t-statistics obtained from the estimation are adjusted for event clustering and event induced variance following Kolari and Pynnonen (2010).[8] These adjusted t-statistics are employed to test whether the CAR significantly differs from zero.

4.4 Results

Tables 4.2 and 4.3 show the financial market reactions to the announcement of the Comprehensive Assessment and the publication of its outcomes, respectively. The tables display the abnormal returns cumulated over a period of three (or more) trading days and averaged across groups of banks. We test whether banks have CARs that are significantly different from zero during our event windows. As Table 4.2 shows, the announcement of the assessment led to a decline in the average CARs of all banks of 2.4 percent but this effect is not significant. Also the CDS-spreads were not significantly affected. The results do not suggest that stock prices and CDS-spreads of gap and no-gap banks reacted systematically different. The same conclusion holds for the publication of the outcomes. Overall, stocks and spreads did not react on the day that the results of the assessment

[6] We have also considered as alternatives the MSCI World Index, Stoxx 600 Banks Index, the Euro Overnight Index Average rate and two-factor models including these indices with national indices. This does not affect our general findings (results available upon request).

[7] We have considered different event windows as well: (-1,0), (0,+1), (-2,0), (0,+2), (-2,+2), (-3,0), (0,+3), (-3,+3), (-7,0), (0,+7), and (-7,+7). We present findings for some of these windows in our tables.

[8] In the presence of event clustering cross-correlation among stocks may lead to the over rejection of the null hypothesis of zero average abnormal returns. Not all recent event studies adjust for clustering (e.g. Candelon and Sy, 2015), but in our view it is the proper procedure. See also Amici et al. (2013), Fratianni and Marchionne (2013), and Elyasiani et al. (2014).

were released, and this holds both for gap banks and no-gap banks.[9]

Next, we differentiate between banks located in two groups of countries, namely the GIIPS countries (Greece, Ireland, Italy, Portugal and Spain) and the other countries in the euro area. As Tables 4.2 and 4.3 show, the results for both groups of countries are similar: both the announcement and the publication of the outcomes of the Comprehensive Assessment generally did not affect financial markets.[10]

Next, we turn to the results per country. Using our standard event window, there is some evidence that the Comprehensive Assessment had an effect on equity returns and CDS spreads. The announcement of the Comprehensive Assessment affected stock prices of Belgian and Portuguese banks negatively (see Table 4.2). The announcement does not seem to have had a significant effect on stock prices of banks in other countries. In Spain there was a negative announcement effect for CDS spreads and in the Netherlands a positive effect. As to the market reaction to the publication of the results of the Comprehensive Assessment we see a mixed picture (see Table 4.3). CARs were affected positively for Austrian and Portuguese banks but negatively for the Irish banks in our sample. News articles obtained from the Dow Jones Factiva database indicate that stock prices of banks for which markets expected worse results than reported increased. In other circumstances, stocks declined mainly due to economic news.[11] For CDS spreads there is less evidence of a market reaction after the publication of the results of the assessment (see Table 4.3). An exception is the decline in spreads for German banks, which may reflect that markets were positively surprised that almost all German banks passed the Comprehensive Assessment.

For longer event windows, the results as shown in Tables 4.2 and 4.3 suggest stock market reactions for some countries (most notably Austria, Belgium, France, and Spain). For example, considering an event window of (-2,+2), i.e. five trading days, the negative market reactions of Belgian, French, and Spanish banks are significant at the 5 percent level. Considering event windows of (-3,+3) and (-7,+7), there is also evidence of negative market reactions for banks in Belgium, Cyprus, France, Malta, and Spain and positive market reactions for banks in Austria. However, there is no evidence of reaction for these banks during a (-1,+1) window.[12] Table 4.3 suggests a similar picture for the reactions in the CDS market. The CDS spreads of French, Spanish, and Dutch banks show positive

[9] If we take somewhat longer symmetric windows, i.e. (-2,+2), (-3,+3), and (-7,+7), we find similar results. Although the CARs after the publication of the results of the Comprehensive Assessment increase in most windows, they are only significantly different from zero at the ten percent level for the stock market for a (-3,+3) window; for CDS spreads the results are always insignificant.

[10] Using a longer window generally does not lead to different results. Again the CARs increase, but they are not significantly different from zero; only for the (-3, +3) window do we find a significant effect in the stock market, but only at the ten percent level.

[11] An example is the news on the decline of the IFO business climate index to a two-year low in October 2014 suggesting that the German economy may face a difficult final quarter of 2014 (Wagstyl, 2014).

[12] An argument in favour of using longer event windows is that it could capture delayed market reactions. However, in longer windows market volatility due to other news may be picked up. For example, for the French banks in Table 4.3, the decrease in stocks for longer event windows seem to be driven by investors' profit-taking after gains in the run-up to the publication of the Comprehensive Assessment (Reuters, 2014) and not so much by the results of the stress test.

Table 4.2
Market reactions to the announcement of the Comprehensive Assessment

Notes: This table shows the average cumulative abnormal returns for all, no-gap, gap, GIIPS, No-GIIPS banks, and per country banks in the stock market (in %) and the CDS market (in bp) in response to the announcement of the Comprehensive Assessment. The average reaction of spreads for the CDS market for GIIPS countries excludes Greece, as no CDS data is available for these banks. The No-GIIPS countries are BE, FR, and DE for stocks and BE, FR, DE, NL, and LU for spreads. This composition is determined by data availability. Reported figures are based on corrected t-statistics. Statistical significance is denoted as follows: *** - 1% ** - 5%, * - 10%.

	Stock market (%)				*CDS market (bp)*			
	(-1,+1)	(-2,+2)	(-3,+3)	(-7,+7)	(-1,+1)	(-2,+2)	(-3,+3)	(-7,+7)
Austria	-1.19	-2.48	-3.29***	.617				
Belgium	-2.78**	6.28	-6.81	-4.01	2.4	3.41	4.56	.836
Cyprus	-4.84	4.52	1.27	25.5***				
France	-.769	-4.19***	-6.27***	-5.05***	1.58	3.83***	4.47***	.787
Germany	-1.24	-2.18	-3.91**	.272	-2.12	.481	2.22	3.27
Greece	3.55	8.92	11.6	12.9				
Ireland	-18.8	-11.4	-12.7***	2.59	1.21	10.8	11.5	8.2
Italy	-2.27	-4.28	-5.79	-1.04	-.95	1.71	6.5	-24.9
Luxembourg					-2.92	-.678	.569	3.73
Malta	.597*	.826***	.034	1.63				
Netherlands					-7.16*	-1.23***	-.829	-8.92
Portugal	-4.84***	-4.21***	-5.21***	-2.29***	-1.84	3.18	13.6	-33.7
Slovakia	-7.7	-6.58	-2.01***	4.84***				
Spain	-1.37	-3.2	-7.32*	-5.69	5.05***	3.57**	11.2***	-3.13
All	-2.44				-.635			
No-gap	-3.24				.046			
Gap	-.97				-3.36			
No-GIIPS	-1.51				-1.65			
GIIPS	-2.74				.377			

Table 4.3
Market reactions to the results of the Comprehensive Assessment

Notes: This table shows the average cumulative abnormal returns for all, no-gap, gap, GIIPS, No-GIIPS banks, and per country banks in the stock market (in %) and the CDS market (in bp) in response to the publication of Comprehensive Assessment outcomes. The average reaction of spreads for the CDS market for GIIPS countries excludes Greece, as no CDS data is available for these banks. The No-GIIPS countries are BE, FR, and DE for stocks and BE, FR, DE, NL, and LU for spreads. This composition is determined by data availability. Reported figures are based on corrected t-statistics. Statistical significance is denoted as follows: *** - 1% ** - 5%, * - 10%.

	Stock market (%)				*CDS market (bp)*			
	(-1,+1)	(-2,+2)	(-3,+3)	(-7,+7)	(-1,+1)	(-2,+2)	(-3,+3)	(-7,+7)
Austria	7.71**	4.64	5.5***	5.1***				
Belgium	-1.84	-4.55**	-3.58	-13.6*	.384	3.19	1.61	4.01
Cyprus	-1.31	-.517	-2.29	-21.5***				
France	-.059	-2.59**	-4.84***	-5.94***	-2.14	.538	1.61	10.5***
Germany	1.28	.287	1.78	2.12	-3.6***	-3.65	2.26	5.12
Greece	.576	-5.31	-11.9	3.23				
Ireland	-6.59**	-4.69	-3.6	-1.71	-6.27	-3.73	-1.59	2.1
Italy	-1.26	-6.24	-10.6	-8.49	-14	-19.8	-19.3	6.95
Luxembourg					-.231	2.8	2.95	7.9
Malta	.42	-.828***	-2.04***	1.24				
Netherlands					-2.19	-3.62	-2.55*	6.45***
Portugal	2.89***	-1.78	-5.85	-7.38	11.3	-14	-9.56	.691
Slovakia	.717	-.633	.601	1.88				
Spain	.855	-4.03	-4.86	-10*	-2.32	5.65	3.05	20.4**
All	-.203				-5.26			
No-gap	.204				-1.98			
Gap	-.954				-18.4			
No-GIIPS	.165				-2.15			
GIIPS	-.7				-8.38			

reactions over longer windows.

As pointed out before, before the results of the Comprehensive Assessment were published, several banks increased their capital position by issuing equity or subordinated debt (like CoCos). Notably banks situated in the periphery did so. Table 4.4 shows the market reactions to the announcement of extra capital issuance by some of these banks. The results suggest some market response, notably for banks located in the periphery. Two Italian banks display a strong reaction in stock prices but not in spreads. The negative sign for stocks could be due to dilution effects that frequently occur after extra capital issuance. Stock prices of Banco Comercial Portugues increased following the announcement of capital issuance.

Finally, we have examined the CARs of those banks that had a shortfall according to Acharya and Steffen (2014a). These authors report higher capital shortfalls under their alternative stress test. If such expectations had been priced in, the publication of the outcomes of the Comprehensive Assessment may have surprised financial markets.[13] As Table 4.5 shows, the publication of the results of the assessment did not affect the stocks and spreads of most of these banks. Only for three Italian banks and one Austrian bank do we find (mixed) reactions. Whereas stock prices of Banca Carige and Banca Monte dei Paschi decreased, stock prices of Credito Emiliano and Erste Bank increased. CDS spreads of all banks were not affected.

Table 4.4
Market reactions to stock issuances

Notes: This table shows the largest stock issuances going back up to 12 months prior to the release of the results of the stress test. We list only those banks that were included in the Comprehensive Assessment. Column "Size" indicates the size of the capital issue (in bln €). Type "A" and "R" denote "Additional" and "Rights" respectively. The final columns indicate the reaction of the stock (in %) and CDS markets (in bp) to the announcement of capital issuance. Statistical significance is denoted as follows: *** - 1% ** - 5%, * - 10%.

	Bank	Size	Type	Date	Stocks	Spreads
Austria	Raiffeisen Bank	2.8	A	21-01-2014		
Germany	Deutsche Bank	6.7	R	18-05-2014	-.9	-1.66
Greece	Alpha Bank	1.2	A	24-03-2014	-8.35	
Greece	Eurobank Ergasias	2.9	A	12-04-2014	-10	
Greece	National Bank of Greece	2.5	A	06-05-2014	-3.07	
Greece	Piraeus Bank	1.8	A	24-03-2014	-2.53	
Italy	Banca Monte dei Paschi	5.0	R	26-11-2013	-13.8**	-25.5
Italy	Banco Popolare	1.5	R	27-01-2014	-15.6***	-11.4
Portugal	Banco Comercial Portugues	2.2	R	24-06-2014	8.75*	

[13] Still, at the time the leverage ratio was not a regulatory measure so it may also be argued that markets would therefore not be affected by shortfalls calculated on the basis of this measure.

Table 4.5
Market reactions to banks with shortfalls under SRISK

Notes: This table shows market reactions to cumulative abnormal returns of listed banks in Appendix 2 of Acharya and Steffen (2014b) that do not pass the SRISK benchmark stress test using a (-1,+1) event window. The "SRISK" and "Shortfall" columns indicate the size of capital shortfalls (in billion €). The final columns indicate the reaction of the stock (in %) and CDS markets (in bp) to the publication of the outcomes of the Comprehensive Assessment. Statistical significance is denoted as follows: *** - 1% ** - 5%, * - 10%.

Country	Bank	SRISK	Shortfall	Stocks	Spreads
Austria	Erste Group Bank	5.92	0	7.707**	
Belgium	Dexia	21.35	.34	-3.907	
Belgium	KBC Group	5.26	0	.2305	
Cyprus	Hellenic Bank Public Co.	.17	.28	-1.312	
France	BNP Paribas	58.03	0	.5754	
France	Societe General	49.48	0	-.6936	2.430
Germany	Aareal Bank	1.56	0	.9000	
Germany	Commerzbank	24.25	0	3.498	.6028
Germany	Deutsche Bank	76.59	0	.8935	3.481
Greece	Alpha bank	.15	0	-3.092	
Greece	Eurobank Ergasias	2.47	4.63	5.820	
Greece	National Bank of Greece	.60	3.43	-5.157	
Greece	Piraeus Bank	1.15	.66	4.733	
Ireland	Gov. Comp. Bank of Ireland	2.16	0	-3.100	
Italy	Banca Carige	1.73	1.83	-12.34***	
Italy	Banca Monte dei Paschi di Sienna	9.87	4.25	-9.329*	-25.46
Italy	Banca Popolare dell'Emilia Rom.	1.88	.13	1.300	
Italy	Banca Popolare di Milano	1.85	.68	-.6946	-.1556
Italy	Banca Popolare di Sondrio	1.02	.32	-2.036	
Italy	Banco Popolare S.C.	5.53	.43	1.401	-21.87
Italy	Credito Emiliano	.46	0	6.421*	
Italy	Intesa Sanpaolo	18.70	0	.6434	-4.431
Italy	Mediobanca	1.03	0	2.697	-6.566
Italy	UniCredit	30.36	0	-1.347	-8.592
Italy	Unione di Banche Italiane S.C.	3.88	0	-1.287	
Portugal	Banco BPI	1.12	0	3.075	
Portugal	Banco Comercial Portugues	2.70	1.14	2.699	
Spain	Banco Bilbao Vizcaya Argentaria	5.61	0	.1066	
Spain	Banco de Sabadell	4.33	0	.8446	-5.181
Spain	Banco Popular Espanol	3.69	0	3.231	
Spain	Banco Santander	23.83	0	-.7634	
Spain	Bankinter	.45	0		-2.707

4.5 Discussion and conclusions

We have studied the market reactions to the ECB's Comprehensive Assessment considering their effects on stock returns and CDS spreads. Our findings indicate that the *announcement* of the assessment had no significant effect on stock prices of banks and CDS-spreads in the full sample. If we groups banks at the country level, we find some evidence for a market response in Belgium, the Netherlands, Portugal, and Spain.

Our results suggest that also the publication of the *results* had no significant effect on stocks or CDS-spreads in our full sample for our standard event window of (-1,+1), i.e. three trading days. On a country level, however, we find some evidence of stock market reaction for Austrian, Irish, and Portuguese banks and reactions in CDS spreads for German banks. Considering longer event windows (5 to 15 trading days) we find (mixed) market reactions in the stock markets of Austrian, Belgian, French, and Spanish banks. Similarly, longer windows lead to evidence of reactions in the CDS markets for French, Dutch, and Spanish banks.

Although our results suggest that the immediate market effects of the Comprehensive Assessment are limited, at least for some banks the assessment has led to increased transparency, as markets responded to the provision of new information. Our finding of a limited market response can be interpreted in two ways. Either, financial market participants had no confidence in the assessment and therefore decided to ignore the publication of its results, or the outcomes of the assessment were in line with market expectations. Although our results cannot rule out the first explanation, in view of market analysts' reactions to the publication of the assessment, we believe that the second interpretation is more likely.

The success of the ECB's Comprehensive Assessment is not primarily determined by short-term market responses. As a result of the exercise, the ECB knows more about the current state of the banks and can use this information in implementing its new responsibility for bank supervision in the Eurozone. Due to the Comprehensive Assessment several banks have enhanced their capital base which may enhance financial stability. Interestingly, some banks which did not have a capital shortfall under the Comprehensive Assessment raised new capital, illustrating that banks' capital management is not only affected by regulatory measures but also by other considerations, such as internal targets and market opportunities.

Chapter 5

The impact of government ownership on bank risk-taking

"I'm afraid I have bad news, gentlemen. We missed the safety net."

As a result of the crisis, many banks were bailed out by their respective national governments. This inevitably led to an increase in the role played by governments in bank ownership. But how do government-owned banks perform?

5.1 Introduction

A conventional view among economists is that government-owned banks are inefficient (La Porta et al., 2002a). This inefficiency may stem from weak governance structures, unstable business models, misaligned incentives, or otherwise a general lack in banking skills resulting in higher costs and lower profitability. Despite these shortcomings, there are several reasons for governments to own banks. Firstly, governments own banks to furnish the development of strategic sectors in the economy (Stiglitz, 1993). Proponents of this view argue that when the social benefits of ownership exceed the costs, state-owned firms contribute to development and overall welfare. Second, government-owned banks can exert control over the types of projects that are financed, which may be, at times, politically motivated (Shleifer and Vishny, 1994). Third, concentrated ownership can incentivise a bank's management to act in the government's best interest thereby overcoming several agency problems.[1] Finally, many academics argue that government ownership of banks may improve overall financial stability (e.g. Davydov, 2016). In the aftermath of the recent financial crisis many banks were exposed to increased credit risks and were hit by troubled loan portfolios. Banks with an over-reliance on short-term wholesale funding from the interbank market faced a severe shortage of liquidity when the crisis materialised. Banks relatively less strained in this process ended up contributing to loan provision.

Particularly, during "crisis time" such as the economic downturn that started in 2008, government-owned banks seem to contribute to the overall stability of the financial system. State-owned banks typically have stable deposits and customer bases and focus less on the maximisation of profits (Sapienza, 2004). One important question that has received scant attention in the literature is how government ownership of banks affects banks' risk taking prior to a downturn. It is not clear what the effect should be as some of the risks on the loan books of banks may be present and rising but may not have as of yet materialised fully resulting in loans becoming non-performing. Specifically, what is the relationship between government ownership and bank risk-taking during a period of accelerated loan growth and an impending build-up of risk in the financial system? How do government-owned banks perform during a boom such as the period 2004–07?

A rich body of research, has analysed the performance and riskiness of government owned banks. Firstly, Iannotta et al. (2007), focusing on the period 1999–2004, compare the performance and risk of a sample of 181 large banks from 15 European countries. They evaluate the impact of alternative ownership models, together with the degree of ownership concentration, on bank profitability, cost efficiency and risk. Their findings indicate that government-owned banks exhibit lower profitability, poorer loan quality, and higher

[1] Early studies arguing in support of this view include Glassman and Rhoades (1980) and Cole and Mehran (1998); later studies conclude differently (e.g. Aebi et al., 2012; Beltratti and Stulz, 2012).

insolvency risk, relative to privately owned banks. Similarly Cornett et al. (2010) examine government-owned banks' performances from 1989 to 2004. Their findings indicate that government-owned banks operated less profitably, held less core capital, and had greater credit risk than privately-owned banks prior to 2001. Other papers focus on the post-crisis period and assess the stability enhancing effects of government-owned banks. For example, Davydov (2016) provides empirical support of this view by documenting that government-owned banks have been less risky than their private counterparts after 2008. Sapienza (2004) argues that government-owned banks engaging in the least risky activities seem to have contributed to financial stability. They also seem to charge lower interest rates than privately owned banks. Finally, many recent papers analyse the pre- and post-crisis periods addressing lending patterns (e.g. Cull and Martinez Peria, 2013; Bertay et al., 2015), bank regulation and supervision (e.g. Laeven and Levine, 2009; Klomp and De Haan, 2012, 2015), and emerging markets effects (e.g. Gonzalez, 2005; Barth et al., 2013; Carvalho, 2014; Chen et al., 2017). Some papers argue in favour of government-owned banks. For example, Bertay et al. (2015) find that government-owned banks tend to lend less procyclically and even countercyclically for advanced economies compared with other banks. Overall, these studies differ considerably in the time period considered, countries included, or in the sample of included banks (which are typically large and mostly listed). Overall the studies seem to agree in favour of government ownership during turbulent times but otherwise show that these banks are typically outperformed by banks that are privately held.[2]

My goal in this study is largely descriptive and complementary. First, in contrast to the existing literature, the approach taken here is to consider a large sample of banks during a relatively short window. The paper provides cross-sectional evidence of bank characteristics of 5319 banks for mostly European countries over the period 2004–2007. My sample consists of mainly non-listed banks (77 percent) of which some banks are directly, or in part, government-owned. Several bank performance characteristics are considered. Second, I consider riskiness indicators for loans and insolvency and evaluate government ownership of banks in the cross-section.

My findings are as follows. First, across the entire sample, government-owned banks perform below average when it comes to bank performance measures. Second, using balance sheet measures for bank riskiness the findings consistently show that if a bank is government-owned it is, all else equal, riskier. This finding holds after controlling for a variety of bank-specific and macroeconomic variables and is robust to alternative measures of bank riskiness. My findings therefore confirm the overal existing view of performance and riskiness of government-owned banks and complement the literature in terms of the size and scope of the data considered.

[2]There are some exceptions. For example, Altunbas et al. (2001) find little evidence that government-owned banks perform less efficiently than private or cooperative banks.

This chapter is structured as follows. Section 5.2 provides a description of the data and variables. Section 5.3 presents the methodology. Section 5.4 discusses the findings. Finally, Section 5.5 concludes.

5.2 Data and variables

This research employs unbalanced bank-level panel data for a sample of 5319 European banks over the pre-crisis period of 2004–07. The data are collected from Bureau van Dijk's Bankscope database and are mainly on bank performance and bank riskiness accounts (to be specified below). Banks not reporting these types of financial statements to Bankscope are not considered in the analysis.

5.2.1 Government ownership of banks

Table 5.1 provides a list of the countries in the sample, as well as a descriptive overview of government ownership. The data consist of mainly non-listed banks (77 percent) with a total amount of 14.439 observations. The number of observations varies across variables due to lack of financial data. The bottom part of the table indicates the bank types included in the sample.[3]

State-owned banks are ubiquitous. Table 5.1 shows that a large fraction of the banks in the sample is, directly or in part, government-owned.[4] According to Iannotta et al. (2013) government-owned banks are mostly located in Austria, Germany, France, and Italy while other countries, such as Finland and Spain, have little or no government-owned banks. As Table 5.1 shows considering a broader set of countries and mainly non-listed banks paints a richer picture: government-owned banks are prevalent in many other countries including the UK and Switzerland. Moreover, in some countries, government ownership seems to have risen over the years. Also, ownership is quite concentrated (not shown) as has been exemplified in other research. For example, Caprio et al. (2007) provide figures of cross-country variation in the average degree of control rights. Overall, the cross-country average for widely held banks is only 25 percent in their sample; so that in the average country, 75 percent of the largest, listed banks have a controlling shareholder (i.e. they do not have a shareholder that owns at least 10 percent of the voting

[3] While considering many bank specialisations provides a more complete picture of the overall effect of government ownership on bank risk taking, in the process one could end up introducing possible biases due to the different natures and business scopes among the banks (because of different objectives and specialisations they have). To account for this possibility I firstly have analysed cross-sample averages of non-performing loans (NPL) accounts to disentangle how they differ according to bank specialisations. The NPLs of most bank types behave similarly, with one exception i.e. Bank Holdings & Holding Companies (BHBC). BHBCs show higher amounts of NPLs overall with a moderate decline between 2004–05. For the remainder of the years NPLs behave very similarly. Secondly, as will be explained later, the analysis includes dummy variables in the estimation taking into account the specialisation of banks.

[4] A bank is typically denoted government-owned when a (significant) fraction of the shares are government-held. As will be discussed in more detail later the size of this fraction varies throughout the literature. For the purpose of demonstrating governments' presence Table 5.1 displays a stake of at least 5 percent ownership by governments.

Table 5.1
Government ownership of banks

Notes: This table shows the list of countries in the analysis and displays the proportion of banks that are, directly or in part, government-owned. The column "All" indicates the total number of banks. "Obs" columns denote the number of observations. "%" gives an indication of the percentage of banks per country in the sample. The "Government ownership" column breaks down by country the number of banks that are government-owned. The data are collected from Bureau van Dijk's Bankscope database.

Country	**All**	**Obs**	**%**	**Government ownership**				**Tot**	**Obs**
				2004	2005	2006	2007		
Albania	10	36	.25	2	1	2		2	5
Andorra	7	19	.13						
Austria	193	564	3.91	9	8	6	8	18	31
Belarus	27	65	.45	12	7	9	10	18	38
Belgium	125	330	2.29	2	2	2	6	7	12
Bosnia-Herz.	24	75	.52	6	5	7	3	9	21
Bulgaria	34	109	.75	2	2	4	2	4	10
Croatia	45	141	.98	2	6	6	5	6	19
Cyprus	33	83	.57	3	3	3	3	4	12
Czech Rep.	47	142	.98	5	7	7	8	13	27
Denmark	96	289	2		2	2	11	12	15
Estonia	13	38	.26	2	4	2		4	8
Finland	32	103	.71	9	5	5	5	9	24
France	628	1689	11.7	39	16	16	14	54	85
Germany	437	1291	8.94	41	39	49	44	87	173
Gibraltar	3	6	.04						
Greece	41	116	.8	6	6	7	13	15	32
Hungary	57	149	1.03	13	5	8	5	17	31
Iceland	22	44	.3	1	1		1	3	3
Ireland	97	273	1.89	2			10	12	12
Italy	606	1612	11.16	11	10	6	33	43	60
Kosovo	16	16	.11	6				6	6
Latvia	36	116	.8	4	4	2	2	5	12
Liechtenstein	18	64	.44	2	2	2	2	2	8
Lithuania	17	64	.44	4	2			4	6
Luxembourg	140	420	2.91	13	12	10	3	19	38
Macedonia	21	57	.39	2	5	5	1	6	13
Malta	18	48	.33	2	2	2	2	2	8
Moldova	20	56	.39	1	1		2	2	4
Monaco	17	48	.33						
Montenegro	7	14	.1		3	3		4	6
Netherlands	159	388	2.69	3	2	4	14	14	23
Norway	85	253	1.75	24	19	12	15	33	70
Poland	70	202	1.4	14	11	12	18	25	55
Portugal	87	223	1.54	4	3	3	11	13	21
Romania	41	126	.87	6	4	2	3	7	15
Russia	506	996	6.9	30	25	36	36	65	127
San Marino	5	8	.06						
Serbia	35	81	.56		8	6	4	10	18
Slovakia	29	85	.59	6	4	5	5	8	20
Slovenia	39	104	.72	13	8	11	6	18	38
Spain	141	399	2.76	3	1	1	11	13	16
Sweden	74	230	1.59	8	8	8	21	21	45
Switzerland	367	1129	7.82	48	46	42	48	73	184
Turkey	141	334	2.31	22	16	18	24	38	80
Ukraine	65	160	1.11	7	3	5	3	10	18
United Kingdom	603	1644	11.39	21	23	21	43	71	108
Bank types									
Holdings	242	598	4.14						
Commercial banks	3017	8347	57.81						
Cooperative banks	410	1040	7.20						
Investment banks	591	1527	10.58						
Islamic banks	9	17	.12						
M&Lt Cred.banks	17	205	1.42						
Cred.Inst.Nonbanks	481	1114	7.72						
Mortgage banks	151	443	3.07						
Savings banks	295	834	5.78						
Cred.Inst. Gov	97	314	2.18						
Unlisted banks		11068	76.7						945
Listed banks		3371	23.3						612
Total	5319	14.439	100					800	1557

rights). Similar figures are found by La Porta et al. (1999). Finally, the table shows that government ownership of banks is higher in some eastern European countries than in most western European countries.

5.2.2 *Variables of interest*

Table 5.2 provides a description of the variables of interest. The list indicates the following measures in evaluating the government ownership of banks: government ownership, bank- and macroeconomic-level controls, and bank performance and riskiness variables. I discuss each in turn.

Ownership variable

Government ownership in the literature is usually denoted as the share of equity owned by the government (cf. e.g. La Porta et al., 2002a). Using this share of ownership indices are constructed according to pre-specified thresholds of government ownership. My approach here consists of a three-step process. First, I check whether the ownership information is provided in Bankscope which records the ownership information of banks. Second, I consult the Zephyr database which documents mergers and acquisitions deals including information on ownership. Finally, I check the homepages of banks for complementary information such as individual banks' financial statements.[5]

Although this information provides insight into the degree of ownership of a bank, ownership does not necessarily equal control.[6] Moreover, ownership can be direct and indirect. Direct ownership involves shares that are registered to a shareholder. Indirect ownership involves shares held by entities, which the shareholder then eventually controls. The principal shareholders of banks are frequently financial institutions or corporate entities, so that to identify the major shareholders in these entities, additional data is required. This paper considers solely direct ownership of banks for reasons that Bankscope only provides financial and ownership information of banks with structural ownership information.

At what threshold can a bank be considered as "government-owned"? La Porta et al. (1999, 2002b), for example, assume banks to have a controlling owner if shareholders have direct or indirect voting rights that sum to 10 percent or more making it sufficient to exert control. If no shareholder holds 10 percent of the voting rights, a bank is usually classified as independent, or "widely held". Moreover, in case multiple shareholders have

[5] Banks that have experienced mergers or acquisitions are treated as follows. If Bankscope continues to use the accounts of the surviving bank for the new entity after a merger or acquisition, the surviving bank remains in the sample. If Bankscope starts a new account for the new entity, banks involved in that merger exit the sample.

[6] This paper solely considers ownership structures. Other methods for shareholders to control enterprises, such as board sizes, compensation schemes, and corporate control are out of this paper's scope. See De Haan and Vlahu (2016) for a survey on the empirical literature on the corporate governance of banks.

Table 5.2
Variables of interest

Notes: This table provides the list of variables that are considered in the analysis. Data on bank level characteristics are collected from Bureau van Dijk's Bankscope database. Macroeconomic level data are obtained from the World Bank World Development Indicators.

Variable	Description	Explanation
	Bank-specific variables	
CAR	Ratio of capital to total assets.	Bank capitalisation level.
COA	Ratio of total operating expenses to total earning assets.	Bank performance measure relating to costs from operating activities.
DAR	Ratio of total deposits to total assets.	Indicates the degree to which a bank's deposits are covered by its assets.
INC	Ratio of total operating income to total earning assets.	Bank performance measure relating to income from operating activities.
LAD	Ratio of liquid assets to subordinated debt.	The ability of banks to match debt withdrawable on a short notice with liquid assets.
LIQ	Ratio of liquid assets to total assets.	Liquid assets may generate a relatively lower return and are less costly to handle.
LLP	Ratio of loan loss provisions to gross loans.	A non-cash expense for banks to account for future losses on loan defaults. A bank making a small number of risky loans will have a low loan loss provision compared to a bank taking higher risks.
LLI	Ratio of loan loss reserves to impaired loans.	Valuation reserve against a bank's impaired loans portfolio on the balance sheet.
LLR	Ratio of loan loss reserves to gross loans.	Valuation reserve against a bank's total loans on the balance sheet, representing the amount thought to be adequate to cover estimated losses in the loan portfolio.
NCO	Ratio of net charge-offs to equity.	Defined as gross amount of loans charged off as bad debt, minus the recoveries collected from earlier charge-offs.
NPL	Number of nonperforming loans.	A higher amount of non-performing loans indicates a bank may have a bad portfolio of loans.
OIR	Ratio of other operating income to revenues.	The extent to which the bank earns non-interest income. Non-interest income, which includes income from fees, commissions and trading activities, tends to be more volatile than interest income. Banks with a larger share of other operating income are therefore expected to be less stable.
PEA	Ratio of pre-tax profit to total earning assets.	Bank performance measure relating to profits from operating activities.
ROA	Return on assets.	Defined as the ratio of profits to total assets.
TA	Log of total assets (in €mln.).	The logarithm of bank size is used to control for bank characteristics that may affect the fragility of individual banks.
TL	Total loans (in €mln.).	Indication on the size the loan portfolio of a bank.
TPL	Total problem loans.	These include loans that are overdue or are restructured but exclude non-performing loans.
	Synthetic variables	
OWN	Government ownership dummy.	Equals 1 when a bank has at least 50 percent government ownership, 0 otherwise.
PL-factor	The principal component of NPL, TPL, LLP.	The risk measure indicates the degree of troubled loans that are on the bank balance sheet.
$\mathcal{Z}$-score	Distance-to-default measure.	Indicates the number of standard deviations the return on assets has to fall below its expected value before equity is depleted and the bank becomes insolvent.
	Macroeconomic control variables	
CAB	Ratio of current account balance over GDP.	Captures uncertainty regarding the current account balance.
CPI	Percentage change in consumer price index.	Captures differences in inflation.
GDP	Growth rate of real GDP per capita.	Captures differences in economic development.
EXC	Change in the exchange rate.	Captures exposure to real exchange rate risk.

over 10 percent of the votes, the largest shareholder is usually chosen as the controlling owner.[7]

However, some papers assume a higher margin of ownership considering minority passive (or active) shareholdings (respectively: less than 20 percent; between 20 and 50 percent). For example, Laeven and Levine (2009) consider a higher margin of ownership and use a 20 percent threshold. Similarly, Chen et al. (2017) consider a 50 percent threshold. I define a bank as government-owned when more than 50 percent of its capital is held by the government. This is threshold is useful for two reasons. Firstly, the advantage with using a majority cut-off is that the effects of government-ownership, if there are any, are likely to become more discernible. Secondly, this benefit may be particularly important in a multi-country sample comprising many types of banks that are subject to different market or regulatory conditions.[8]

Control variables

Table 5.2 considers a variety of bank- and macro-level control variables that are used when considering the ceteris paribus effects of government ownership on bank riskiness. First, I control for the size of banks, using the log of total assets and the bank capitalisation level, using the capital to asset ratios of banks. I also control for the easiness of access to external sources of financing by including a dummy indicating whether a bank is listed on a stock exchange during the sample period. Second, to control for some macroeconomic developments that are likely to affect the quality of bank assets, I control for the growth rate of real GDP per capita and the inflation rate to account for the cyclicality of bank stability (e.g. Marcucci and Quagliariello, 2009). Real GDP is calculated by using nominal GDP adjusted by the GDP deflator. To capture adverse economic shocks increasing uncertainty or exposure to foreign exchange risk I include data on the current account balance and exchange rate changes following Beck, T., and Demirgüç-Kunt, A., and Levine, R. (2006) and Klomp and De Haan (2015). The macro data are obtained from the World Bank World Development Indicators (WDI).

Performance and riskiness variables

The remainder of Table 5.2 presents variables on bank performance measures such as the return on assets and the ratios of operating-profit, income, and cost to total earning assets. Lastly, the table presents (balance sheet) riskiness measures for banks such

[7] A 10 percent threshold is commonly used under the International Financial Reporting Standards (IFRS) and the Generally Accepted Accounting Principles (GAAP) accounting standards.

[8] Indeed, the choice of threshold may not be inconsequential in itself as the results depend on what threshold one employs. For example, Shehzad et al. (2010) show, that in their sample an ownership threshold of 50 percent leads to a significant and positive effect of ownership concentration on the capital adequacy ratio while no such effect is found for lower ownership stakes (i.e. 10 and 20 percent).

as non-performing loans, total problem loans, ratios of respectively loan-loss provisions and loan-loss reserves to gross loans (cf. e.g Dinger and Von Hagen, 2009), and insolvency riskiness. For the latter, I consider a distance to default measure denoted $\mathcal{Z}$-score following Roy (1952).[9] The $\mathcal{Z}$ indicates the number of standard deviations the return on assets has to fall below its expected value before equity is depleted and the bank becomes insolvent. A higher $\mathcal{Z}$-score indicates, ceteris paribus, that the bank is more stable.[10] Following Demirgüç-Kunt et al. (2008) I use the logarithm of $(1 + \mathcal{Z})$ to smooth out higher values of the $\mathcal{Z}$-score and avoid losing observations with a dependent variable of zero.

5.3 Methodology

My baseline econometric specification is as follows,

$$\text{risk}_{ij,t} = \alpha + \beta \cdot \text{owner}_{ij,t} + \gamma \cdot \text{listed}_{ij,t} + \delta \cdot \text{control}_{ij,t} + \zeta \cdot \text{macro}_{ij,t} + \eta \cdot \text{other}_{ij,t} + v_{ij,t} \quad (5.1)$$

where $\text{risk}_{ij,t}$ denotes the measure of bank riskiness for bank i in country j at period t, $\text{owner}_{ij,t}$ indicates state ownership, $\text{listed}_{ij,t}$ indicates whether a bank is listed, $\text{control}_{ij,t}$ is a vector of control variables at the bank level, $\text{macro}_{ij,t}$ is a vector of macro control variables, $\text{other}_{ij,t}$ denotes time and country control variables, and finally $v_{ij,t}$ is the composite error term with c_i the unobserved individual effect and $u_{i,t}$ the white noise error term.

The model in (5.1) is estimated using the fixed-effects estimator.[11] I use heteroskedasticity and within-panel serial correlation robust standard errors and cluster standard errors at the country-level.

5.4 Empirical results

Next the empirical results are discussed. First, a variety of bank performance measures are evaluated. The chapter then continues with discussing the main effects of government ownership on bank riskiness.

[9] The insolvency riskiness of bank i in country j is calculated,

$$\mathcal{Z}_{ij,t} = \left(\mu_{ij,t} + \frac{E_{ij,t}}{A_{ij,t}}\right) / \sigma_{ij,t}$$

where A denotes assets, E equity, and μ and σ are respectively the mean and standard deviation of the return on assets of bank i in country j at time t. If profits follow a normal distribution the inverse of the probability of insolvency is $\mathcal{Z}_{ij,t}$.

[10] There are a variety of ways to measure the risk of a bank. I consider solely cross-sectional riskiness measures between banks. Several papers employ stock market data using, e.g. the volatility of equity returns as an alternative measure of bank risk (as in Saunders et al., 1990; Esty, 1998). Although the use of (sophisticated) market-based measures of bank riskiness, such as interest rate on certificates of deposits, bank bond prices, and credit default swap spreads are widely used in the literature, this study refrains from these measures as using these would limit the scope of the paper to listed banks only.

[11] I use the fixed-effects estimator based on a Hausmann test that shows the regressors are correlated with time-invariant bank-specific variables, making fixed effects preferable over random effects.

5.4.1 Univariate tests

Table 5.3 provides an overview of bank performance and other operating ratios and contrasts these with banks that are government-owned. The top panel contrasts a variety of sample means and standard deviations. Focusing, firstly, on the $\mathcal{Z}$-score the distance to default for non-government-owned banks is distributed with a mean value of 3.447 and a standard deviation .0231. The figures for the set of all banks are respectively 3.633 and 1.127 with the range of the $\mathcal{Z}$-score (-1.855, 13.94). The fairly high standard deviation and the wide range of $\mathcal{Z}$-scores imply a considerable variation in the level of riskiness across banks. The $\mathcal{Z}$-score for government-owned banks is higher at 4.048 and standard deviation 1.405. Figure 5.1 provides a plot of the $\mathcal{Z}$-scores.

Panel b. of Table 5.3 breaks a variety of these operating performance down by year and contrasts these with banks that are government-owned. The numbers presented are cross-sample averages weighted by the size of bank balance sheets. Many papers argue for the relative inefficiency of government-owned banks. Table 5.3 confirms this view. For example, the ratio of pre-tax profit to total earning assets is for all years consistently lower across the entire sample for government-owned banks.[12] The same holds for the return on assets. Considering the loan ratios in the table some interesting patterns emerge. For example, the ratio of loan loss reserves to gross loans, capturing the total amount necessary to cover estimated losses in the loan portfolio, is consistently higher for government banks. Loan loss provisions are much higher initially for government-owned banks although they show a large drop in 2007. Demirgüç-Kunt and Huizinga (2010) argue that a bank increasing non-interest income-generating activities increases the rate of return on its assets. There is some evidence of this for non-government-owned banks over the period 2004–07. Other riskiness measures, such as net charge-offs, show mixed pictures.

Overall, the results confirm the view that government-owned banks are less profitable and less efficient than the sample average.

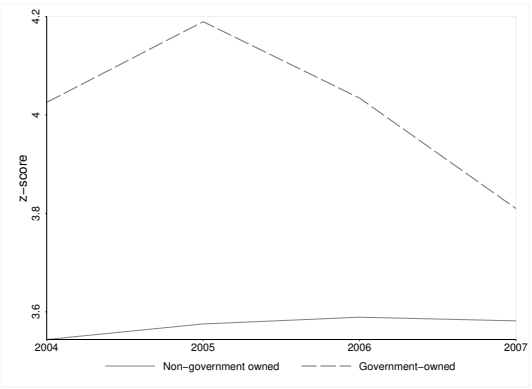
5.4.2 Bank riskiness

Table 5.4 columns (1) to (4) present the main findings. The analysis starts with the benchmark scenario including a government ownership dummy, bank characteristics, and a ticker indicator in column (1). Columns (2) to (4) then subsequently add bank specialisation dummies, macro-level controls, and time and country dummies, respectively. A bank is ceteris paribus more stable the higher is its $\mathcal{Z}$-score. The coefficients of the government ownership indicator in columns (1) to (4) are consistently negative and significant suggesting that when a bank is government-owned it is, all else equal, less stable. In light of prior research pointing out that state-owned banks have higher insolvency and

[12] Following Demirgüç-Kunt and Levine (2004) before tax performance measures are considered.

Figure 5.1
Distance-to-default: $\mathcal{Z}$-score

Notes: This figure plots the distance to default measure for government-owned banks and contrasts it with non-government owned banks, and all banks. The figures are cross-sample averages. The insolvency riskiness of a bank is calculated $\mathcal{Z}_{ij,t} = (\pi_{ij,t}/A_{ij,t} + E_{ij,t}/A_{ij,t})/\sigma_{ij,t}$ following Roy (1952).



credit risks (Iannotta et al., 2007; Cornett et al., 2010) the findings here are corroborating. The risk impact of bank-level control variables is as follows. Bank size is negatively associated with the $\mathcal{Z}$-score implying that larger banks are engaged in riskier activities. Moreover, stability is enhanced with higher capital to assets ratios. The positive coefficients for the ticker indicator imply that when banks have easier access to outside financing this seems, all else equal, to affect stability positively. The remainder of the controls are of macroeconomic nature and indicate that financial stability tends to increase with real GDP per capita growth but declines with the current account balance.

Columns (5) to (6) report findings for a subset of the sample considering only listed banks. The coefficients for government ownership are again negative (and greater in magnitude) suggesting that banks that are listed, and have easier access to outside financing, take more risk when they are government-owned. The final columns (7) to (9) in Table 5.4 consider different riskiness measures. Specifically, the ratio of impaired loans over gross loans in column (7), the ratio of loan loss reserves over gross loans in column (8), and a composite variable, PL-factor, the principal component of the amount of non-performing loans, total problem loans, and loan loss provisions banks make in column (9).[13] The higher these figures are for a bank the riskier, ceteris paribus, the loan portfolio is. Considering column (7) to (9) the findings show that, although the explanatory power of these models is rather weak, overall, government ownership of banks is associated with riskier loan portfolios.

[13] This composition is determined by loan variables that have the least missing observations in the sample.

Table 5.3
Univariate tests

Notes: This table provides an overview of bank performance measures and contrasts these with government-owned banks by year. The table shows operating ratios: the ratio of total operating income to total earning assets (INC), the ratio of total operating expenses to total earning assets (COA), the ratio of pre-tax profit to total earning assets (PEA), the return on assets (ROA), the ratio of capital to assets (CAR), the ratio of liquid assets to subordinated debt (LAD), the ratio of liquid assets to total assets (LIQ), loan loss provisions (LLP), the ratio of loan loss reserves to gross loans (LLR), the ratio of loan loss reserves to impaired loans (LLI), the ratio of net charge-offs to equity (NCO), the ratio of other operating income to revenues (OIR), the ratio of non-performing loans to gross loans (NPL), the ratio of deposits to assets (DAR). Table 5.2 provides a description of the variables of interest. The final column in panel a. performs a difference in means test between non-government-owned banks and government-owned banks taking into account the size of banks. A regular t-test with panel data would not work in this case as the observations are clustered and therefore not independent. The approach here is constructing a new variable as the difference between means and performing a fixed effects regression on the new variable. The resulting significance of the constant term is a reasonable approach to test the equality of the means. Statistical significance is denoted as follows: *** - 1% ** - 5%, * - 10%. In panel b. the table provides cross-sample averages weighted by total assets by year and contrasts these with banks that are not government-owned.

		Non-gov banks		**Gov banks**		
	a. Comparison of means	Mean	Std.dev.	Mean	Std.dev.	$P > \|t\|$
CAR	Ratio of capital to assets	.1483	.1847	.1777	.2084	***
DAR	Ratio of deposits to assets	.6385	.2559	.5774	.2754	***
LAD	Ratio of liquid assets to subordinated debt	29.27	309.7	118.5	1052	***
LIQ	Ratio of liquid assets to assets	.1787	.2171	.1542	.1691	***
LLI	Ratio of loan loss reserves to impaired loans	130.05	144.1	115.8	99.45	***
LLP	Ratio of loan loss provisions to gross loans	.0839	.4446	.1082	.4552	***
LLR	Ratio of loan loss reserves to gross loans	3.819	7.770	6.507	10.33	***
NCO	Ratio of net charge-offs to equity	.0531	.8889	.0328	.0751	***
NPL	Ratio of non-performing loans to gross loans	.0451	.1156	.0812	.1762	***
OIR	Ratio of other operating income to revenue	.1412	.4600	.1333	.2096	***
PEA	Ratio of pre-tax profits to earning assets	.0685	1.483	.0162	.0359	***
ROA	Return on assets	.0166	.0526	.0120	.0238	***
$\mathcal{Z}$	Log of (1 + $\mathcal{Z}$-score)	3.447	.0231	4.048	1.405	***

		Non-gov banks				**Gov banks**			
	b. Operating performance by year	2004	2005	2006	2007	2004	2005	2006	2007
CAR	Ratio of capital to assets	.1473	.1493	.1494	.1471	.1712	.2005	.1658	.1731
COA	Ratio of operating cost to earning assets	.1974	.1588	.5956	.8184	.04	.0476	.0327	.0257
INC	Ratio of operating income to earning assets	.2756	.2114	1.542	.882	.0561	.0573	.0531	.044
LIQ	Ratio of liquid assets to assets	26.8	30.1	26.1	25.1	27.8	31.2	21	14.3
LLP	Ratio of loan loss provisions to gross loans	.0924	.0925	.0749	.0777	.1425	.1772	.0619	.0365
LLR	Ratio of loan loss reserves to gross loans	4.1	4.3	3.5	3.5	6.5	8.4	5.5	4.2
NCO	Ratio of net charge-offs to equity	.031	.1347	.0287	.0336	.0411	.0438	.0318	.0073
OIR	Ratio of other operating income to revenue	.1115	.1408	.1588	.1453	.1407	.1718	.1347	.0862
PEA	Ratio of pre-tax profits to earning assets	.07	.0544	.0784	.0706	.0157	.0115	.0202	.0174
ROA	Return on assets	.0131	.0172	.0188	.0172	.0103	.0102	.0149	.0134

Table 5.4
The impact of government ownership on bank risk-taking

Notes: This table shows the estimation results to Equation 5.1. Columns (1) to (4) present the main findings. Columns (5) to (6) present the findings for a subset of the sample considering only listed banks. Columns (7) to (9) consider the impact of government ownership on the number of impaired loans, loan loss reserves, and non-performing loans. Table 5.2 provides a list of all the variables considered in this paper. Robust standard errors in parentheses. Statistical significance is denoted as follows: *** - 1% ** - 5%, * - 10%.

VARIABLES	(1) Full sample	(2) Full sample	(3) Full sample	(4) Full sample	(5) Listed banks	(6) Listed banks	(7) IMPL	(8) LLR	(9) PL
Government ownership	-.0891**	-.0888**	-.0851**	-.0708*	-.121***	-.0957*	1.134**	.807***	.193*
	(.0341)	(.0343)	(.0362)	(.0357)	(.0424)	(.0486)	(.421)	(.225)	(.0985)
Log of assets	-.131***	-.131***	-.160***	-.186***	-.144***	-.171***	-1.341*	-1.398*	.0547*
	(.0275)	(.0275)	(.0288)	(.0286)	(.0512)	(.0598)	(.698)	(.753)	(.0306)
Capital assets ratio	2.633***	2.634***	2.527***	2.451***	2.138***	2.064***	2.180	7.041*	.109
	(.276)	(.276)	(.280)	(.260)	(.405)	(.385)	(6.141)	(3.861)	(.0834)
Listed	.0671***	.0658***	.0488**	.0338					
	(.0222)	(.0219)	(.0205)	(.0254)					
Current account balance			-.0066***	-.0049**	-.0097**	-.0081**	-.0716	-.0007	.0066*
			(.0023)	(.0018)	(.0037)	(.0031)	(.0563)	(.0296)	(.0037)
CPI			-.002	-.0029	-.0066	-.0099	-.0668	-.0625	-.001
			(.004)	(.0047)	(.0074)	(.007)	(.0753)	(.0503)	(.0082)
GDP growth			.0001**	.0001*	.0001***	.0001***	.0002	.0003**	.00003
			(.00002)	(.00002)	(.00001)	(.00002)	(.0005)	(.0002)	(.00002)
Exchange rate			.0006	.0006	.0007	.0001	.0969	.0377	.0027
			(.0014)	(.0015)	(.0036)	(.0033)	(.0729)	(.03)	(.0037)
Year dummy 2005				.0173*		.0251**	-.228	.106	.0248
				(.00856)		(.00930)	(.325)	(.163)	(.0182)
Year dummy 2006				.0480***		.0589***	-.402	-.0187	.0165
				(.00979)		(.0142)	(.448)	(.203)	(.0252)
Year dummy 2007				.0417***		.0463*	-.373	-.140	.0455
				(.0120)		(.0243)	(.687)	(.358)	(.0277)
Commercial banks		-.0646*							
		(.0381)							
Mortgage banks		.149							
		(.303)							
Savings banks		-.0767							
		(.0661)							
Constant	4.226***	4.267***	4.374***	4.570***	4.204***	4.492***	5.932	1.08**	-.739*
	(.240)	(.249)	(.267)	(.287)	(.441)	(.496)	(6.814)	(4.684)	(.411)
Bank specific controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Macro controls	N	N	Y	Y	Y	Y	Y	Y	Y
Time fixed effects	N	N	N	Y	N	Y	Y	Y	Y
Country fixed effects	N	N	N	Y	N	Y	Y	Y	Y
Observations	10,972	10,972	10,223	10,223	2,471	2,471	4,078	6,151	11,311
R-squared	.497	.497	.508	.514	.481	.490	.016	.015	.012
Number of bank_index	3,329	3,329	3,144	3,144	725	725	1,832	2,504	4,105

5.5 Discussion and conclusion

Focusing on a large sample of mainly non-listed banks during a period of exuberance facilitates an in depth discussion concerning the performance of government-owned banks and allows for a stark contrast with existing studies. The findings in this study are corroborating. First, the descriptive findings indicate that government-owned banks are ubiquitous and, across the entire sample, perform below average when it comes to bank performance measures. Second, using balance sheet measures for bank riskiness the findings consistently show that if a bank is government-owned it is, all else equal, riskier. It seems that even during an exuberant boom government ownership of banks is inefficient and ceteris paribus more risky. The findings are important from a policy and societal perspective. It is useful for supervisors to consider the different impact their policies may have on banks depending on their ownership pattern as ignoring it may lead to incomplete or erroneous conclusions about the impact of capital regulations, deposit insurance, and activity restrictions on bank risk taking (Laeven and Levine, 2009).

Although focusing on (smaller) non-listed banks allows one to draw broader conclusions there may be some caveats nonetheless. These relate primarily to the differences between the banks, their shareholders, and their supervisory authorities. I address each in turn.

There are many types of banks in the sample and the differences may range from their specialisations to their sheer size. For the latter, considering only large banks in the sample may indeed enhance comparability by reducing concerns that accounting or otherwise liquidity differences would drive the findings. I proceed in two ways addressing this concern. First, as explained earlier, bank-specific and macroeconomic-wide controls are included in the analysis. Second, only banks that comply with accepted international accounting standards are considered in the analysis. Moreover, to capture the fact that some banks may have more liquid shares than others, the analysis is performed on a subset of the sample taking into account only listed banks.

Another caveat lies in the fact that shareholders and regulation influence the risky incentives of banks. Existing research points to the value of examining bank riskiness considering both ownership structures and bank regulations as banks with more powerful owners may take greater risks.[14] Laeven and Levine (2009), for example, note that disregarding cashflow rights of the largest shareholders may disregard the incentives of owners toward risk or the ability of owners to influence risk. Moreover, if minority shareholders are hardly protected they may be unable to exert effective control over management (Shleifer and Vishny, 1997). This is consistent with the hypothesis that small, diversified shareholders are unlikely to be important in countries that fail to protect their rights. I

[14] A somewhat early example is deposit insurance, which may promote risky incentives of owners (Merton, 1977; Keeley, 1990).

address these concerns by employing a high margin of government ownership. Shehzad et al. (2010) note that as shareholder protection improves, the effect of ownership concentration becomes positive and as supervisory control increases the impact reduces. In other words, ownership concentration matters less when regulatory control is stronger and vice versa.

Chapter 6

Conclusion

"What comes after trillion?"

Regardless of the causes of the crises, the role of policy is, and always will be, of extreme importance to the economic outcomes that have been achieved and are to be achieved.

This thesis has addressed questions ranging from macroeconomic stability to financial stability and the role of policy. Specifically, the following research questions were discussed:

- What is the role of mortgage interest deduction in household indebtedness, foreclosures, and macroeconomic fluctuations?
- How did supervisory bank stress tests, conducted in the aftermath of the crisis, affect financial markets?
- How did government-owned banks perform in the build-up to the crisis?

In Chapter 2 a model is developed to analyse the macroeconomic effects of mortgage interest deductions. There are three main findings. First, a higher mortgage interest deduction leads to higher house prices, more levered households, and a higher rate of mortgage default. Second, with a high mortgage interest deduction consumer spending falls more sharply in the presence of negative shocks. Third, when mortgage risk is high the presence of mortgage interest deduction leads to more volatile responses of the main macro-variables to exogenous shocks. Both the empirical and the theoretical evidence presented support the idea that mortgage interest deductibility may be a relevant factor in the occurrence of foreclosures.

Chapter 3 quantifies the market reactions of US stress tests performed after the start of the financial crisis by considering their effects on stock returns, CDS spreads, systematic risk, and systemic risk. Considering stock markets, the findings indicate that the publication of stress test results had little effect on stock returns. The clarification event in 2009 by then Fed chairman Bernanke and the results of CCAR in 2012 did affect stock markets positively. Considering credit markets, our findings show evidence of a decline in CDS spreads following the release of the stress test results in 2009, 2012, and 2013. In other words, stress tests may have provided information to markets. Our analysis of banks' betas suggests that the publication of stress test results has affected banks' systematic risk in 2009 and 2013. Studying the changes in betas we find that stress tests reduced systemic risk in 2009 and 2012. Overall, we conclude that stress tests have produced valuable information for market participants and can play a role in mitigating bank opacity. The findings suggest that stress tests are a useful tool in mitigating systematic and systemic risk in stock and credit markets.

Chapter 4 studies the market reactions to the ECB's Comprehensive Assessment considering their effects on stock returns and CDS spreads. The findings here suggest that the release of information about the stress test did occasionally move markets. The immediate market effects of the Comprehensive Assessment are limited but for some banks the assessment has led to increased transparency, as markets responded to the provision of new information. The finding of a limited market response can be interpreted in

two ways. Either, financial market participants had no confidence in the assessment and therefore decided to ignore the publication of its results, or the outcomes of the assessment were in line with market expectations. Although the results cannot rule out the first explanation, in view of market analysts' reactions to the publication of the assessment, the second interpretation is more likely. However, the success of stress tests is not primarily determined by short-term market responses. As a result of the exercise, regulators know more about the current state of the banks and can use this information in implementing enhanced supervisory polices. Moreover, due to stress tests banks have enhanced their capital base, in both the US and the Eurozone, which may enhance financial stability.

Chapter 5 employs a large sample of mainly non-listed banks during a period of exuberance and assesses the performance of government-owned banks. The findings in this chapter are corroborating. First, the descriptive findings indicate that government-owned banks are ubiquitous and, across the entire sample, perform below average when it comes to bank performance measures. Second, using balance sheet measures for bank riskiness the findings consistently show that if a bank is government-owned it is, all else equal, riskier. It seems that even during an exuberant boom government ownership of banks is inefficient and ceteris paribus more risky. The findings are important from a policy perspective. It is useful for supervisors to consider the different impact their policies may have on banks depending on their ownership pattern as ignoring it may lead to incomplete or erroneous conclusions about the impact of capital regulations, deposit insurance, and activity restrictions on bank risk taking. In addition, the findings suggest that banks that were nationalised during the financial crisis should be denationalised.

Based on the findings in each chapter, this thesis suggests the following key points concerning the role of policy.

- It is important to understand housing market outcomes in the context of macroprudential policy. Policies aimed at aiding home owners on a microeconomic level may prove dangerous from a macroeconomic perspective.
- In contrast, policies designed to assuage markets in dismay by pushing for more information and transparency may prove very beneficial from a financial stability perspective. Moreover, assessments such as stress tests enable the regulators forward that cause.
- Considering the pre-crisis period of 2004–07, which displayed a tremendous rise in debt, the conventional view among economists remains unscathed: Government ownership of banks is inefficient and ceteris paribus more risky. This implies that banks that were nationalised during the financial crisis should be denationalised.

Collectively, the findings suggest that regardless of the causes of the crises, the role of

policy has been, and always will be, of extreme importance to the economic outcomes that have been achieved and are to be achieved.

Chapter 7

Summary in Dutch

Dit proefschrift bevat vier essays over het belang van macroeconomische en financiële stabiliteit en de rol van beleid.

In hoofdstuk 2 wordt een model ontwikkeld om de macro-economische effecten van hypotheekrenteaf-trek te analyseren. Er zijn drie belangrijke bevindingen. Ten eerste, een hogere hypotheekrenteaftrek leidt tot hogere huizenprijzen, hogere schuldenlast van de huishoudens en, in evenwicht, meer wanbetalingen. Ten tweede, met een hoge hypotheekrenteaftrek dalen de consumentenbestedingen sterker in de aanwezigheid van negatieve schokken. Ten derde, wanneer het hypotheekrisico hoog is, leidt de aanwezigheid van hypotheekrenteaftrek tot meer volatiele reacties van de belangrijkste macrovariabelen op exogene schokken. Zowel het empirisch als het theoretisch bewijs dat wordt gepresenteerd ondersteunt het idee dat hypotheekrenteaftrek mogelijk een relevante factor is in het voorkomen van wanbetalingen.

Hoofdstuk 3 is gezamenlijk werk met Ekaterina Neretina en Jakob de Haan en kwantificeert de marktreacties van de Amerikaanse stresstesten die uitgevoerd zijn na de financiële crisis. Het hoofdstuk bestudeert wat de effecten van stresstesten zijn op aandelen rendementen, CDS-spreads, systematisch risico en systeemrisico. Rekening houdend met aandelen markten, geven de bevindingen aan dat de publicatie van stresstest resultaten weinig effect heeft gehad op aandelen rendementen. De kredietmarkten, in tegendeel, tonen een daling van de CDS-spreads aan na de publicatie van de stresstest resultaten in 2009, 2012 en 2013. Met andere woorden, stresstesten hebben mogelijk informatie aan de markten opgeleverd. De analyse van markt beta's suggereert dat stresstesten het systematische risico van banken in 2009 en 2013 hebben beïnvloed. De veranderingen in beta's laten daarnaast zien dat ook het systeemrisico in 2009 en 2012 is verminderd. Aan de hand van de bevindingen wordt de conclusie getrokken dat stresstesten waardevolle informatie hebben opgeleverd voor de markten en daardoor een rol kunnen spelen bij het vermeerderen van de transparantie in het bankwezen. De bevindingen sugger-

eren dat stresstesten een nuttig hulpmiddel zijn bij het mitigeren van systematisch en systemisch risico op aandelen- en kredietmarkten.

Hoofdstuk 4 is gezamenlijk werk met Jakob de Haan en bestudeert de reacties van de financiële markten op de Comprehensive Assessment van de ECB, rekening houdend met de effecten op aandelenrendementen en CDS-spreads. De bevindingen hier suggereren dat het vrijgeven van informatie over de stresstest de markten beperkt hebben beïnvloedt. De beperkte marktreactie kan op twee manieren worden geïnterpreteerd. Mogelijk hadden de financiële markten geen vertrouwen in de beoordeling en besloten daarom de publicatie van de resultaten te negeren of, aannemelijker, de uitkomsten van de beoordeling waren in lijn met de marktverwachtingen. Alhoewel de resultaten de eerste verklaring niet kunnen uitsluiten, is de tweede interpretatie waarschijnlijker gezien de reacties van marktanalisten op de publicatie van de beoordeling.

Het succes van de stresstesten in Hoofdstukken 3–4 wordt echter primair niet bepaald door korte-termijn marktreacties van de markten. Als gevolg van de exercities weten toezichthouders meer over de huidige staat van de banken en kunnen ze deze informatie gebruiken om het toezicht beleid te verbeteren. Bovendien hebben banken in zowel de VS als in de eurozone vanwege stresstesten hun kapitaalbasis verhoogd wat mogelijk de financiële stabiliteit heeft doen toenemen.

Hoofdstuk 5 bestudeert voornamelijk niet-beursgenoteerde banken tijdens een periode van financiële uitbundigheid in de markten en beoordeelt de prestaties van banken die in bezit zijn van de overheid. De bevindingen in dit hoofdstuk zijn bevestigend met die van de literatuur. Ten eerste laten de resultaten zien dat overheidsbezit van banken alomtegenwoordig is en, in de cross-sectie, onder-gemiddeld presteren als het gaat om prestatie-indicatoren voor banken. Ten tweede tonen de bevindingen, met behulp van balansmaatstaven voor bankrisico's, consequent aan dat als een bank eigendom van de overheid is, het risicovoller is. Het lijkt erop dat zelfs tijdens een periode van buitensporige groei in leningen overheidseigendom van banken inefficiënt is en, ceteris paribus, riskanter.

Chapter 8

Acknowledgements

Most acknowledgements are soon forgotten. This creates a form of moral hazard for the writer. If you are not going to remember my words, I may have no incentive in crafting them. The net effect is what economists call a bad equilibrium. Sometimes, though, equilibria are extrinsically random. Let me therefore recognise the people without which this thesis would not have existed.

This thesis is the result of challenging years of research and policy at De Nederlandsche Bank, Sveriges Riksbank, and the University of Groningen. My time at these organisations allowed me to learn from leading academicians and economists in the world and witness the beauty of research and policy in Macroeconomics and Finance. In the process, I have learned that research can be a tough and absorbing job.

These last years have been exceptional for me and they would not have been so if it wasn't for my main advisors Jakob de Haan and Frank Smets. I am, and always will be, in their debt. I am very fortunate for having met Jakob and received his support early on in my career, for his invaluable advice, and for our casual chats. I am also very grateful to Frank who has provided me with guidance ever since my Master studies. Finally, I am thankful to Andrea Colciago who stepped in as a co-advisor at a later stage.

I had the pleasure of discussing my research with several economists, policymakers, and academicians. Let me briefly address them by chapter. Chapter 2 has benefitted greatly from discussions with and or comments of Lawrence Christiano, Jordi Galí, Simon Gilchrist, Michel Juillard, Junior Maih, Albert Marcet, Enrique Mendoza, Tommaso Monacelli, Vincent Sterk, seminar participants at De Nederlandsche Bank, Norgesbank, Sveriges Riksbank, Bank of Finland, Central Bank of Turkey, Ca'Foscari University of Venice, and the University of Groningen. Chapters 3 and 4 have benefitted from comments and or discussions by Viral Acharya, Torben Andersen, Dirk Bezemer, Rob Nijskens, Maarten van Oordt, Andreas Pick, Auke Plantinga, Rodney Ramcharan, Robert Vermeulen, Razvan Vlahu, Wolf Wagner, Chen Zhou, and conference participants of the

joint Duisenberg School of Finance/Tilburg University banking research day in Amsterdam, the 3rd EBA policy research workshop in London, the ESRB/RiskLab/Bank of Finland conference in Helsinki, and seminar participants at the Wirtschaftsuniversitat Wien, De Nederlandsche Bank, and the University of Groningen. I am also greatful to former colleagues at DNB's Financial Markets and Financial Stability Divisions for data support. My final chapter, Chapter 5, benefitted from discussions with and or comments of Christina Cella, Neeltje van Horen, Iman van Lelyveld, and Arthur van Soest.

These last years I was fortunate enough to share my time with many exuberant (former) colleagues at DNB, the Riksbank, the University of Groningen, and the University of Amsterdam. I am profoundly grateful that they took an interest in my research and let me discuss theirs' with them. At De Nederlandsche Bank I enjoyed many conversations with Andrea, Ayako, Chen, David-Jan, Irma, Gabriele, Maarten, Manu, Pierre, and Vincent. At the University of Groningen I enjoyed most of my talks with Irina and Wen. At the Riksbank, I enjoyed my lunches and afternoon coffees with Christina, Daniel, Daria, Dilan, and Paulo. Finally, at the University of Amsterdam, I had fun conversations with Christian, Dirk, Franc, Massimo, Ward, and many others.

I'm grateful to the reading committee: Professors Sylvester Eijffinger, Kasper Roszbach, and Raf Wouters, for their time and effort in reading and providing feedback. I am honoured to have such academically and professionally distinguished scholars on my committee. My special thanks to Kasper Roszbach and his support during my final months at the Riksbank.

My gratitude and sincerity is deep towards my family and friends who have always supported me. I would especially like to thank my mother Kaniye.

As it turns out, promises are hardly forgotten. Perhaps, above all, I owe the most to Dutch taxpayers. A debt I intend to repay.

For this group of people without which this thesis would not exist, I offer my deepest gratitude.

Cenkhan Sahin January 21, 2018

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